AGRICULTURAL ENGINEERING

Published by the AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

Executive Office of the Society: Saint Joseph, Michigan.

ARNOLD P. YERKES, *President* RAYMOND OLNEY, *Secretary-Treasurer*

VOLUME 19 FEBRUARY 1938 NUMBER 2

CONTENTS

EDITORIALS 53

DIRECT GRAPHIC SOLUTION OF TERRACE OUTLET CHANNEL DIMENSIONS 55
By V. W. Thalmann

A PLOW THAT BUILDS CONTOUR FURROWS 57
By Xzin McNeal

A STATE-WIDE FARM BUILDING PROGRAM 59
By Deane G. Carter

THE WARMING OF MILK IN TRANSIT 61
By John E. Nicholas

EXPERIMENTAL STUDIES IN TERRACING 63
By Dwight D. Smith

DISTILLATE AS A TRACTOR FUEL 67
By E. L. Barger and J. L. Gale

REMODELING POSSIBILITIES FOR FARM HOMES 72
By H. E. Wichers

THE DYNAMIC PROPERTIES OF SOIL 73
VII. A Study of the Nature of Physical Forces Governing the Adhesion Between Soil and Metal Surfaces
By F. A. Kummer and M. L. Nichols

WHAT AGRICULTURAL ENGINEERS ARE DOING 78

NEWS 82

AGRICULTURAL ENGINEERING DIGEST 86

Published monthly by the American Society of Agricultural Engineers. Publication office at Benton Harbor, Michigan. Editorial and advertising departments at the executive office of the Society, St. Joseph, Michigan . . . . Price $3.00 a year, 30 cents a copy; to members $2.00 a year, 20 cents a copy. Postage to countries to which second-class rates do not apply, $1.00 additional . . . . The Society is not responsible for statements and opinions contained in papers published in this journal; they represent the views of the individuals to whom they are credited and are not binding on the Society as a whole . . . . Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921 . . . . The title AGRICULTURAL ENGINEERING is registered in U. S. Patent Office. Copyright, 1938, by American Society of Agricultural Engineers.

District Auxiliary of Farm Equipment

WHEREVER nature or some other consideration imposes operating problems too big for independent action by the individual farmer, organized community or district action by all the farmers involved is a logical solution. Community engineering projects and operating equipment are implied. This tractor and grader are the property of an irrigation district in Idaho, and are being used to maintain one of the main canals of the district. Water supply projects for irrigation farms are an early form of group action involving agricultural engineering. Soil conservation associations and various projects to provide facilities for cooperative marketing are newer examples. As relations between machine size, investment, operating cost, and capacity are reduced to common principles, the fields for economic use of various sizes of farm machines will be more clearly defined. This may be expected to indicate further opportunities for realizing, by group use, the high efficiencies possible with large machines.

AGRICULTURAL ENGINEERING

VOL 19, NO 2 EDITORIALS FEBRUARY 1938

The Chemurgic Research Endowment

CHEMURGY has a research endowment, which is interesting not only in fact, but in the research philosophy represented and the proposed initial angle of approach.

In announcing the endowment, Michigan State College, where the work is to be centered, points out that publicly supported research can, generally speaking, cover only the immediate problems of agriculture. On the other hand, some of the major advances of agriculture have been indirect results of research in other fields. For example, it states that the radio has contributed more to raising farm living standards and satisfactions than any other one development, yet the research in physics which made possible radio development could hardly have been justified as agricultural research. The endowment was therefore made and is to be used in the spirit of supplementing publicly supported research, especially with investigations in new and unexplored fields beyond the range of publicly supported studies.

The trustees of the Rackham Foundation, which provided the endowment, are said to believe that the general field of industrial utilization of agricultural products holds problems and possibilities "as unexplored as were those of the internal-combustion engine and the pneumatic tire, or the radio, a little over a half century ago," and that "solution of any one of these problems may affect agriculture as profoundly as industrial research of the type just mentioned."

A problem tentatively picked as a starting point represents a new approach to drought, soil erosion, and flood control. The idea is to try to develop out of ordinary farm waste materials, such as straw or corn stalks, a semi-permanent or permanent material that can be incorporated with soil to give it a more spongy texture and to increase its water-absorbing and water-holding capacity, and to devise means of producing it in quantity at a practicable cost.

However practical or impractical this may sound or prove, it will be agreed that it approaches an important problem from an original angle. We have enough faith in the merit of new and refreshing viewpoints and angles of approach to technical problems to be confident that, in the long run, the endowment will be more than justified by practical results.

Unified Engineering Representation

ORGANIZATIONS are created by groups of individuals to do things which those individuals have found they cannot do by and for themselves, acting individually. Federations of organizations have been created to do things which their member organizations cannot do by and for themselves. American Engineering Council seems to be in a position of having to justify its existence in terms of what it is doing or can do for its member organizations and their individual members, which those member organizations cannot do, acting alone.

Professions have long recognized problems and obligations of public service, of increasing public understanding of their special fields, and of giving service to individual members. In engineering the question is to what extent can these functions be accomplished by the various organizations representing the engineers in special techniques, functions, and geographic locations, and to what extent can they be furthered by broader organization in any form. The question is bigger than that of American Engineering Council as such.

To the extent that public service involves individual specific problems falling clearly within the boundaries of organized technical or functional groups of engineers, their individual organizations can and should meet the problem. To the extent that public service involves definitely local engineering problems, local organizations of engineers should be equal to their solution. But what of national problems, obligations, and opportunities for engineers to be of national public service, involving more than one engineering technique or functional field? Can engineers render the greatest public service by meeting public engineering questions as one body, or as one hundred separate bodies?

Keeping public understanding enlightened and abreast of progress in any technical field is a major problem. The public is the engineering profession's clientele, in both public and private works and opportunities. It will be a better satisfied and more profitable clientele if it can be given clearer conceptions of engineering viewpoints, possibilities, and limitations. Should the public be left to gain its necessarily general and sketchy appreciation of engineering from the conflicting pronouncements of a hundred organizations, or should there be one united organization to make clear the principles, philosophy, and ideals upon which a united engineering profession does agree, and to state frankly varying engineering viewpoints on matters of varying opinion among engineers?

And where should any one engineering organization be able to go first for understanding and support, for a project in its field which needs outside support, if not to a national body representing the whole professional field of engineering?

Specific engineering societies easily justify their existence, but can any one of them adequately represent the whole engineering profession, or even serve its own membership fully without the help of an organization representing the whole engineering profession? American Engineering Council may or may not be making the most of its opportunities, but is not the need of unified engineering representation even greater than when Council was organized? Some revision of form of organization, of representation, and of policy, might improve effectiveness, but should Council's rich experience and many of its concepts of service be scrapped?

Let engineers revamp the whole setup for national representation of engineering as one profession if necessary, but may they never renounce its field of service!

Human Factors in Research

AGRICULTURAL engineering research personnel seem to be experiencing that healthy itching of self-dissatisfaction which leads to progress.

Members of the ASAE Committee on Research are currently considering a broad analysis and proposal of their chairman, E. A. Silver, looking toward means by which the committee may foster progress in agricultural engineering research.

Briefly, Mr. Silver's proposal emphasizes the human factors in research, including the need of mutual understanding and agreement as to the nature of research, and the inherent personal characteristics which, with training, qualify a man to do real research.

The resident teaching and extension fields of agricultural engineering have arrived at more or less uniform and accepted principles of personnel selection, minimum standards of training in methods as well as subject matter, and effective procedures. But research has been anybody's game. It has, by lack of definition, been confused with testing, statistical analysis, invention, design, development, and other individual phases of research and related efforts. It has been further led into superficiality in some cases by part time work, pressure for early results, and insufficient funds, in the face of deeply involved basic considerations. Some administrators have been reluctant to chart the paths by which their research men should sail uncharted seas, lest they prevent valuable discoveries.

It is plain that some standards for agricultural engineering research and research workers would be helpful alike to them, their administrators, and their successors. Without agreement as to what agricultural engineering research is, there can be no agreement as to what qualifications it requires, or how they may be found and developed. Agricultural engineering research men themselves should be best qualified to define their field and its requirements. Mr. Silver's proposal is that the research committee do this job to the extent of setting up something for the rest of the agricultural engineering research men to accept, reject, or revise. We can think of nothing that would do more to foster progress in agricultural engineering research.

A Mechanical Prototype

THE MISSING link between small garden tractors and the two-plow and larger sizes of farm tractors has been supplied, experimentally at least. It was due to come, sooner or later, considering the extent of the potential market.

Beyond its implications to its particular manufacturer, it is of interest to agricultural engineers as a mechanical prototype. What will be its influence on farming and on the tractor industry? Will it do as much to make farmers power-wise, or efficiency-minded, as Ford's old Model T did to make them transportation-minded?

To the extent that it is efficient, adaptable, and within the reach of the small farmer, a tractor of this size will release him from dependence on animal power and labor problems. Rolling about his forty acres, more or less, from crop to crop and job to job, in full control of a handy power source and responsive operating equipment, may give him a new understanding of his power and production efficiency problems.

The majority of farmers being potential users, all the full-line implement manufacturers and some others may be expected to soon offer tractors scaled to the size, adaptability, and price requirements of the small farmer. Individual farmers' responses to the new stimulus will be varied and unpredictable. If or when the new size gets into the hands of several hundred thousand small farmers, some trends may, however, be noted. We would not be surprised to see trends toward more intensive and efficient use of land, and toward acreage adjustments to meet the newly-found operating capacity. And satisfactory experience with a small tractor may reasonably be expected to lead some farmers toward use of larger tractors and a larger variety of mechanical and electrical equipment.

A satisfactory small tractor may do more to sell the principles of efficient farm operation than any other one thing. It may be expected to lead to better farming and to better days for both farmers and farm equipment manufacturers.

Engineering and the Sciences

A NEAT distinction between the physical and social sciences, in relation to engineering, was drawn by Wm. E. Wickenden in his recent address as retiring chairman of Section M (Engineering) of the American Association for the Advancement of Science[1].

Being faced in any new engineering proposition, with the two questions "Will it work?" and "Will it pay?", the engineer can find in physical science many guiding principles and data to help him determine what is physically possible and practicable, but he can as yet find little in social science to help him determine whether it may be profitable or socially desirable.

Still the engineer has to answer the question "Will it pay?" and is therefore interested in the social sciences as a possible source of clues to the answer. Dr. Wickenden intimated that college courses in the social sciences can give engineers little more than a foundation for understanding. He indicates that engineers may well continue study in the social field after graduation in search for "the premises of practical action which men draw from social laws and doctrines."

Dr. Wickenden also intimated that the understanding relation between physical scientists and engineers sets a good example for a possible similar understanding between social scientists and engineers. Physical scientists are primarily interested in their science as such, in developing truth for its own intrinsic value. Engineers are interested in it as a source of tools to aid in engineering work. Each understands and respects the other's place and sense of values. If social scientists find engineers invading their fields, these scientists may be sure that the engineers are not seeking to appropriate these fields, but are only looking hopefully for additional tools of possible use in engineering work.

[1] "Mechanical Engineering," Vol. 60, No. 2 (February, 1938).

Direct Graphic Solution of Terrace Outlet Channel Dimensions

By V. W. Thalmann

AFTER THE maximum rates of runoff to be expected during the design frequency have been determined, the design of terrace outlet channels to be protected by sod or other vegetation usually resolves itself into the problem of providing a channel in which a specified maximum velocity of flow will not be exceeded for a given maximum rate of flow and a given channel grade. Since the required rate of flow in the channel will increase as each additional terrace discharge is accumulated, and since the channel grade may vary in different sections in order to conform to surface topography, it necessarily follows that a number of different cross-section designs will be required for each channel. To solve each of these cross sections by the trial-and-error method is a tedious and laborious process, and even the direct mathematical solution described by H. O. Matson in AGRICULTURAL ENGINEERING August 1935 consumes a considerable amount of time when several different sections are to be designed. In order to speed up and simplify the work in designing outlet channels, the author developed, and for the past two years has used, the following graphic method for direct solution of channel cross sections, and it has proven to be a rapid and easy method of design.

From the desired maximum velocity of flow, V, in feet per second, the given grade, S, in per cent, and the assumed roughness coefficient, n, the required hydraulic radius, R, of the channel cross section can be readily determined by the use of Fig. 1. This chart is a graphic solution of the Manning formula for the range of conditions ordinarily encountered in terrace outlet channel design in Region 4 of the Soil Conservation Service, which in-

Approved by the Soil Conservation Service, U. S. Department of Agriculture, for first publication in AGRICULTURAL ENGINEERING.

Author: Associate agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. Mem. ASAE.

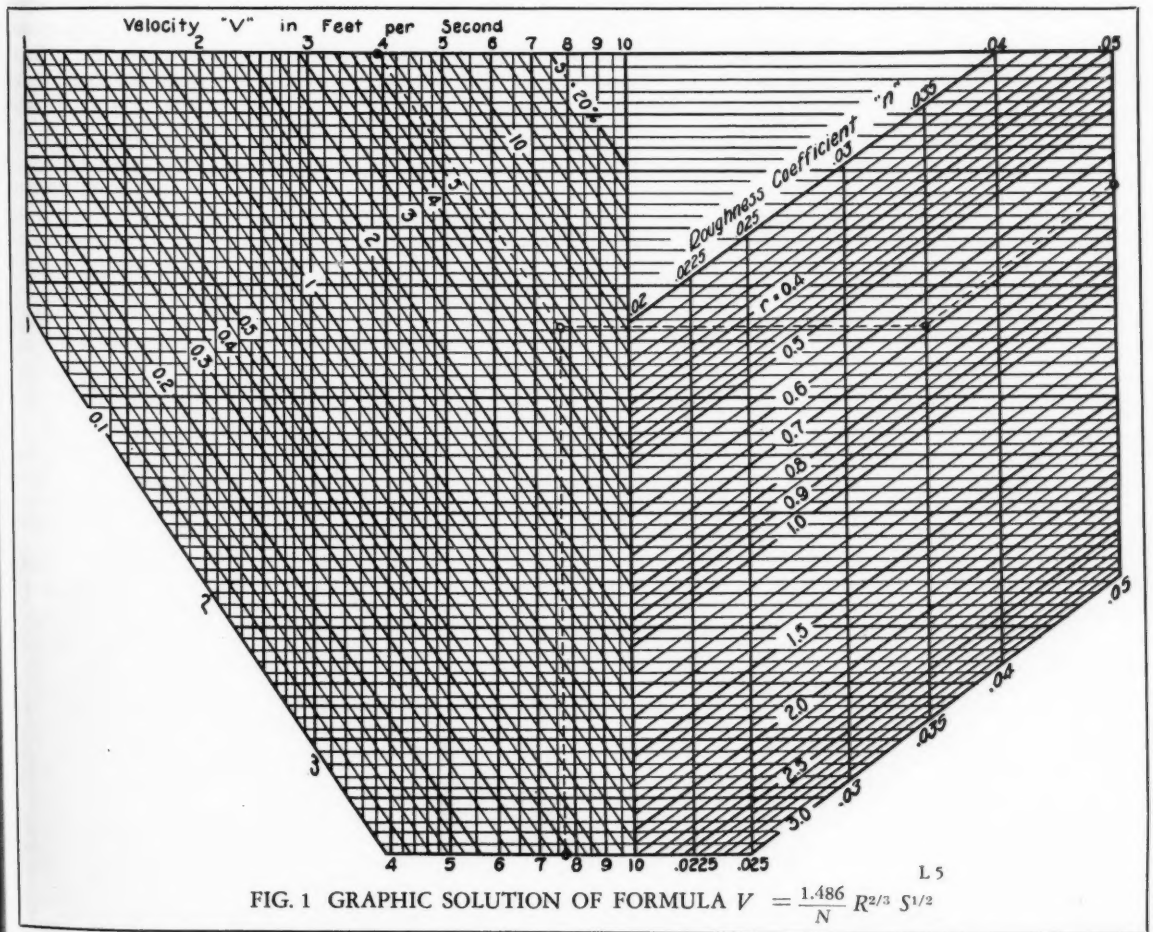


FIG. 1 GRAPHIC SOLUTION OF FORMULA $V = \frac{1.486}{N} R^{2/3} S^{1/2}$

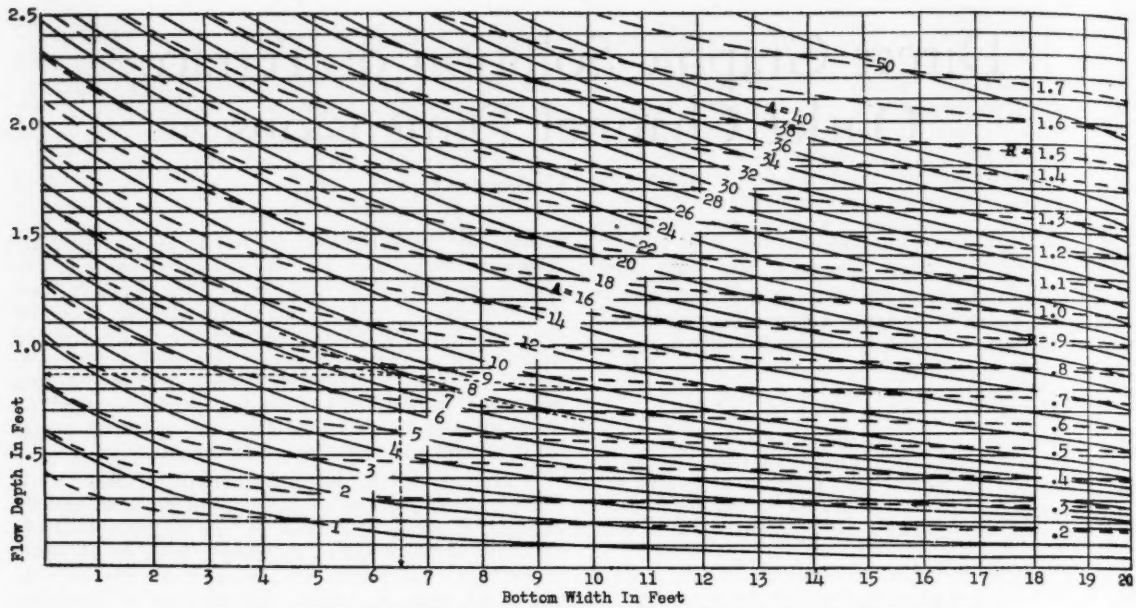


Fig. 2 SOLUTION OF CHANNEL DIMENSIONS BY HYDRAULIC RADIUS AND CROSS-SECTIONAL AREA FOR CHANNELS WITH 3 TO 1 SIDE SLOPES

cludes the states of Arkansas, Louisiana, and all of Texas, with the exception of the Texas panhandle. After determining the required value of R, the required cross-sectional area, A, in square feet is found by dividing the given rate of flow, Q, (determined as described later) by the desired velocity of flow, V. Then from the intersection of the required A and R curves on Fig. 2, the required flow depth and bottom width for a channel with 3 to 1 side slopes may be read on the horizontal and vertical scales. Charts similar to Fig. 2 were plotted for various side slopes ranging from 1 to 1 to 6 to 1 to provide a selection of any desired shape of cross section. *(Continued on page 58)*

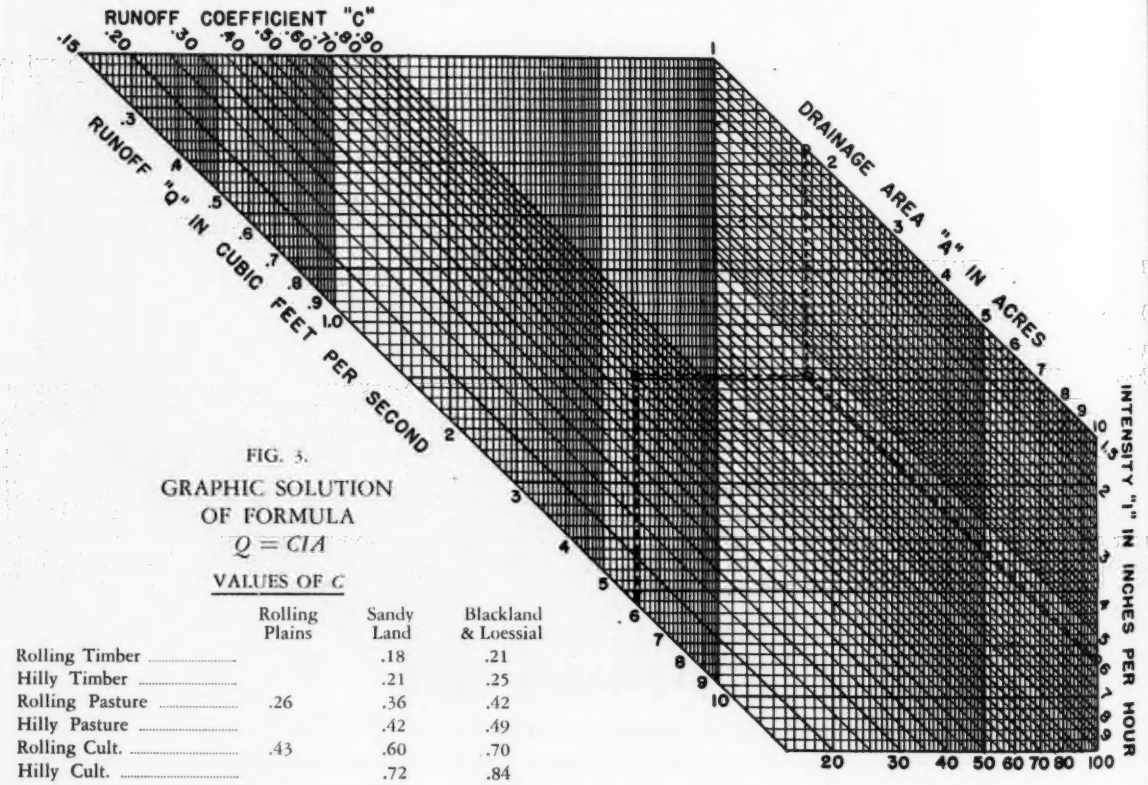

RUNOFF COEFFICIENT "C"
.15 .20 .30 .40 .50 .60 .70 .80 .90
RUNOFF "Q" IN CUBIC FEET PER SECOND
DRAINAGE AREA "A" IN ACRES
INTENSITY "I" IN INCHES PER HOUR

FIG. 3.

GRAPHIC SOLUTION OF FORMULA $Q = CIA$

VALUES OF C

	Rolling Plains	Sandy Land	Blackland & Loessial
Rolling Timber		.18	.21
Hilly Timber		.21	.25
Rolling Pasture	.26	.36	.42
Hilly Pasture		.42	.49
Rolling Cult.	.43	.60	.70
Hilly Cult.		.72	.84

A Plow That Builds Contour Furrows

By Xzin McNeal

THE FIRST part of my study of contour furrows in pastures was to make a field survey of some forty farms in five Missouri counties where contour furrows had been built. Interviews with farmers and inspection of their pastures gave some valuable information on the problem in general. Some of the visits to the farms were made in August when pastures were in the dormant stage, but the effectiveness of the furrows could be seen in the more dense stand of grass near the furrows. Opinions of farmers were obtained as to the effectiveness of the practice, and in all cases the farmers favored it. In some cases, however, they would have changed the spacing or the size of furrows if they were to do the work over. For example, three men owning farms on Shelby silt loam had pastures contoured with the following intervals: 18 ft on a 15 per cent slope, 20 ft on a 10 per cent slope, and 30 ft on a 5 per cent slope. In each case the men suggested that closer spacing of the contour furrows would be much more effective in preventing runoff and conserving moisture. Numerous other similar examples could be cited.

Every farmer interviewed was interested in knowing how he could make the contour furrows without destroying so much of the sod. Figures gathered on this survey showed an average spacing of furrows of 21.5 ft with a disturbed width, either plowed or covered, of 4.8 ft. The disturbed area is, therefore, 22.3 per cent of the total. The average slope of contoured pastures covered in this survey is 8.9 per cent.

The farmers interviewed were asked for an estimate of the percentage runoff after contouring, assuming a 30 per cent runoff before contouring. The estimates of runoff after contouring varied from zero to 23 per cent and averaged 6.05 per cent. If these estimates are reliable—and they appear to be—the contour furrows are saving about 24 per cent of the total rainfall which would otherwise run off. It would appear, therefore, that contour furrowing is quite a valuable practice. It is also estimated by the farmers that the carrying capacity of their pastures is increased in direct proportion to the amount of water conserved by the contours.

The cost of making the contour furrows, according to farmers' own estimates, and exclusive of the services rendered by technical men of the Soil Conservation Service, averaged 82 cents per acre on thirty farms. Many methods of construction were tried, but in all cases moldboard plows were finally used for making the furrows. Following are some of the furrow combinations used: Two furrows down, two up and two down, one up and one down, two down and one up, three down and three up with a tractor gang, and one 18-in furrow down with a 12-in plow following in the same furrow, also throwing down hill. This last combination built a very good furrow with a minimum disturbed area, but, as with the other combinations, the sod was inverted and considerable subsoil brought to the surface.

Blocking or damming the furrows at frequent intervals greatly increased their effectiveness. Where a system of blocking is used, the problem of water concentration does not become serious. Where a furrow breaks over, the concentration in the furrow below is not apt to be serious if the furrows are blocked or dammed. In all cases where the contours were not blocked, there was evidence of spilling over at the low places.

The average water-holding capacity per foot of the furrow length was found to be 0.65 cu ft. With a horizontal spacing of 22.5 ft, which was the average found on this survey, this holding capacity is inadequate for a normal rainfall.

After analyzing the problem from various viewpoints, it was decided to design and build a contour furrowing plow which would meet, if possible, the following requirements:

1 Disturb the least possible area of sod

2 Make a ridge capable of impounding the water from an average rain

3 Keep the sod top side up, with no subsoil exposed

Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Ill., December 2, 1937. Contribution of the agricultural engineering department, Missouri Agricultural Experiment Station, Journal Series 545.

Author: Research assistant in agricultural engineering, University of Missouri.

(LEFT) THE MISSOURI CONTOUR FURROWING PLOW. (CENTER) PROFILES OF UNDISTURBED SOIL AND OF FURROW SURFACE. (RIGHT) PASTURE CONTOURED WITH THE MISSOURI PLOW

4 Be reversible, to save time and lower cost of making the furrows

5 Have a draft light enough so that it could be pulled by a two-plow tractor.

With these objectives in mind, a machine shown in the accompanying illustration was designed and built. It consists essentially of an 18-in tractor sulky equipped with both a right-hand bottom and a left-hand bottom to form a large lister. The upper parts of the frogs were cut away and the rear parts of the moldboards cut off. The curvature of the moldboards was also reduced considerably so as to lift the furrow slices more gently and avoid inverting them. Long, gently-curved steel slats were fastened to the rear of the moldboards to hold the sod up, while a disk, fastened immediately behind and under the moldboards, moves soil from under the upper furrow slice and throws it beneath the lower furrow slice to form the ridge.

The machine is made reversible by mounting the disk on a short beam, which can be swung from side to side about a pivot point at the rear of the plow beams. The disk is mounted with the plane of the cutting edge making an angle of 28 deg with the vertical, and an angle of 50 deg with the forward line of travel. Adjustment of the disk beam enables the disk to be set to cut from 5 to 7 in below the bottom of the furrow made by the lister. A large serrated coulter has been found to be very effective in cutting the sod and weeds, and in giving a uniform furrow slice with which to form the ridge. A pair of cast iron rollers is used to bring the sod in closer contact with the new surface upon which it rests. The rollers are trailed behind the plow by a pipe hitch.

The machine has been pulled by two different tractors —a Caterpillar 22 and an Allis-Chalmers WC, equipped with rubber tires. All tests have been on Putnam silt loam soil, most of which was in bluegrass sod. The machine was pulled by the Caterpillar in third gear, except when in the toughest sod, where second gear was required. When pulling the machine with the Allis-Chalmers, first gear was required to operate satisfactorily. This tractor was used, however, only on excellent bluegrass sod. On all tests with each tractor, the lister part of the machine was operated at 5 in deep and with the disk cutting 6 in deeper into the subsoil. The disk penetrated and operated quite satisfactorily, even in hard, dry subsoil.

The machine has been operated on sod in various degrees of cover, ranging from excellent bluegrass to barren pastures. The best work, of course, was done on good bluegrass sod. In good sod the machine has consistently built ridges which have an effective height of 6 in, and which are 9 in higher than the bottom of the furrow after the sod strip has fallen in. With a vertical interval of 0.6 ft, the furrows will impound the heaviest rain which may be expected once in ten years.

Direct Graphic Solution of Terrace Outlet Channel Dimensions

(Continued from page 56)

The rate of flow is determined by the rational runoff formula

$$Q = CIA$$

where Q is the rate of flow (runoff) in cubic feet per second; C is a coefficient depending upon the runoff characteristics of the watershed, and is equivalent to the percentage of rainfall that appears as runoff; I is the rainfall intensity in inches per hour, and A is the drainage area in acres.

Fig. 3 is a graphic solution of this formula, and the values of the coefficient, C, shown thereon were developed for use in Soil Conservation Service Region 4 by Mr. Matson. Since the intensity factor will depend upon the time of concentration of the watershed, the use of the chart in any given locality can be simplified by plotting time of concentration lines corresponding to the expected intensities for the locality and the frequency period used as a basis for design. In this manner, the value of Q may be read directly as a function of area, time of concentration and runoff coefficient without figuring intensities. Rainfall intensities corresponding to various times of concentration of from 5 minutes to 24 hours for all parts of the United States can be found in U. S. Department of Agriculture Miscellaneous Publication No. 204, "Rainfall Intensity-Frequency Data", by David L. Yarnell. More detailed data applying specifically to the state of Texas is available in Texas Reclamation Department Bulletin No. 25, "Excessive Rainfall in Texas", by A. M. Vance. It will be noted that in the use of Fig. 3 the values for A may be read as 0.1 to 1, 1 to 10, 10 to 100 and so on, provided corresponding factors are applied to the resulting determined values of Q.

To illustrate the use of the charts, let us assume that it is required to design a channel for a velocity of between 7.5 and 8 ft per sec with 3 to 1 side slopes on a grade of 5.5 per cent and draining 17.5 acres under an expected maximum rainfall intensity of 5.9 in per hr, with assumed roughness and runoff coefficients of 0.035 and 0.60, respectively. By reading Fig. 1 as indicated by the dotted line key solution, it is found that a hydraulic radius of 0.675 will be required. As indicated by the key solution on Fig. 3, a maximum rate of flow of 61 cu ft per sec may be expected, which for a channel velocity of 7.75 ft per sec will require a channel with a cross-sectional area of 7.9 sq ft. Reading from the intersection of the $A = 7.9$ and $R = 0.675$ curves on Fig. 2, we find that a channel with approximately 0.88 ft flow depth and 6.5 ft bottom width will be required.

Figs. 1 and 3 were prepared by transposing each formula to the form

$Q/C = IA = X$ (using the rational formula as an example) and plotting the two equations against each other on logarithmic cross-section paper. After plotting the equations, the logarithmic X values were replaced with evenly spaced horizontal guide lines to simplify the reading of the charts. Fig. 2 was prepared by plotting the equations

$$A = bd + cd^2$$

and

$$R = \frac{bd + cd^2}{b + 2\sqrt{d^2 + (cd)^2}},$$

in which b = bottom width of channel in feet
d = flow depth of channel in feet
c is the cotangent of the angle of side slope.

A State-Wide Farm Building Program

By Deane G. Carter

THE PROBLEM of developing effective assistance in farm and home building for extension service programs has concerned agricultural engineers for many years. Lyle[1] found that in a 10-year period, 1924-33, extension workers assisted in planning about 2,312 dwellings per year or slightly more than 2 per cent of the estimated annual rural homes constructed. In a survey of 6,000 Illinois farms made in 1928, Lyle reported that 53.2 per cent of the farmers obtained their information and advice concerning improved building practices from local lumber companies, and only 11.7 per cent recognized help from the extension agents.

Plan Production. The first efforts toward the production of farm building plans was undertaken about 1910; and from 1910 to 1920 most of the principal departments of agricultural engineering of the state colleges and universities and the U. S. Bureau of Agricultural Engineering were engaged in the production of plans for use in the respective states and for general use. The colleges of agriculture in the Middle West have produced from 100 to 900 plans each, some of which are special plans, while others are standard plans, essentially duplicates of plans used in nearby states.

The first comprehensive effort to develop an adequate plan production, without excessive duplication, was the organization of a committee from colleges of agriculture in the Middle West, under the sponsorship of the American Society of Agricultural Engineers. The Midwest Plan Service Committee selected more than 100 plans of the most widely used farm buildings, eliminated duplicate plans, and redesigned or revised the entire list with competent architects and draftsmen. At first by an "exchange" service assisted by the Bureau of Agricultural Engineering, and later by its own efforts, the Midwest plan tracings were made available to the states.

Plan production was stimulated by the Civil Works Administration program in 1934, through the employment of architects in 17 states and the Bureau of Agricultural Engineering, for the development of new and remodeling plans for farm homes. This program resulted in the production of Farmers' Bulletin 1738, "Farmhouse Planning," and other state and federal publications.

Research findings have stimulated the production of plans designed to incorporate the best recommendations into a variety of structures.

Factors Affecting Demand for Plans. The CWA housing survey, conducted in practically every state in 1933-34, gave the first comprehensive picture of farm housing conditions and needs based upon factual information. The survey revealed a startling need for new construction, repairs, remodeling, and alteration of dwellings; a definite need for better farm building construction and more adequate utilities equipment. Interest aroused by the survey has been a potent factor in stimulating home improvement.

Public attention has been drawn to housing and building needs by state and federal programs, such as the TVA, REA, RRA (now FSA), FHA, and the like. While some of these programs affected only a few farmers, they were important factors in directing attention to rural needs.

A series of years that brought drought, floods, low prices, and reduced incomes to farmers generally delayed the normal building and repair work on farms, and created a backlog of demand that has not yet been met.

Experiment station, extension service, and commercial developments have contributed new recommendations, new methods, and new materials; and organized programs in extension have created wide interest in specific structures.

Publications. Experiment station bulletins, extension service circulars, and USDA farmers' bulletins serve a vital purpose in carrying building information to the farm patron. For specific structures, such as poultry houses, swine houses, trench silos, livestock equipment, and the like, sufficient information is carried in the printed publications.

In the case of the farm home and major service structures, the bulletin is not sufficient to cover the wide range of size, type, style, method, and material necessary to permit adaptation to all situations. On the other hand, the production and distribution of blueprint plans is obviously too costly without some check on indiscriminate use. The illustrated plan catalog or handbook seems to meet the need for illustrative material in the best way found so far. The Midwest catalog was the first publication of this type, and is now in the second edition. The book, "Building Plans for the Northeastern States", has been developed cooperatively and published by the Government Printing Office.

By the use of the handbook, it is possible for the county agent, extension specialist, lumber dealer, or vocational teacher to select the plan that most nearly meets the individual need, and the farmer can study the plan or perspective and order the blueprint plan to meet his specific requirements.

A State Farm and Home Building Program. The mere production of plans will not be effective, unless distribution and use follow. The handbook alone will not function unless properly distributed. The blueprint plans will not be ordered unless a reasonably good service is offered, and an educational program projected to create interest and desire.

Arkansas, in common with a number of other states, cooperated in the Midwest Plan Service; contributed one or two designs to Farmers' Bulletin No. 1738; published several station bulletins and extension circulars on buildings and equipment; and over a period of years produced some 300 plan sheets for buildings adapted to the needs of the state. Several hundred blueprints have been distributed annually, and a number of buildings erected from department plans. For example, 500 canning and food-processing centers were erected under the CWA program.

Realizing the need for improved farm and home buildings, the director of the Arkansas Agricultural Experiment Station and Extension Service appointed a special committee to study the problem and make recommendations

---

Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Illinois, November 30, 1937. Research Paper No. 499, Journal Series, University of Arkansas.

Author: Professor of agricultural engineering and head of the department, University of Arkansas. Mem. ASAE.

[1]Lyle, S. P. "Outlook for improving farm homes", paper presented at the Farm Family Living Conference, Washington, D. C. (October 28, 1935.)

for an extension program. The basis upon which the committee study was undertaken included the following:

1 The farm housing survey, the experiences of extension workers, and the evident interest of farm organizations revealed a very great need for a housing program in the state.

2 Homes and farm buildings represent a vital factor in the lives of farm people, and buildings are associated in some degree with almost every phase of extension work; therefore, it was agreed that the responsibility for a building program was far more than a technical responsibility of agricultural engineering.

3 Farm incomes have been generally low ($600 in Arkansas in 1936), and it is impossible to attain a desirable standard of housing and building by the usual commercial methods. There is a wide variation in incomes, and careful attention must be given to housing needs at various levels of size, quality, and equipment facilities.

4 There is an abundance of native and local building material in the state, in the form of stone, logs, sand, gravel, and local sawmill lumber, available at little or no cash cost, or by barter and exchange. There is ample local labor available, on the farm or in the community, competent to do much of the work of building construction. It might be possible for the farmer to utilize the materials of nature and the labor on the farm for the production of improved housing in the same manner that farm resources are used for crop or livestock production.

5 No building program could be completely successful without plans, illustrative material, publicity, construction helps, and the support of the entire organization to make such helps available.

6 Plans must be available to extension agents as working tools, without delay or restriction if used for project demonstrations.

7 The interest and support of lumber dealers, farm organizations, vocational teachers, and community leaders would add to the success of the program.

With the foregoing factors in mind, a building improvement program was outlined, adopted, and put into operation. The various phases of preparation and initiation of the program are outlined below:

Illustrative Material. A plan service handbook was authorized to illustrate the principal building plans in perspective and floor layout. Some 16 sheets of illustrative material were purchased from the Midwest Plan Service, consisting of widely used basic plans. To supplement these sheets, two architectural draftsmen, college trained, were employed to delineate additional plans which had been developed by the state experiment station. Fifty-six sheets of original drawings were prepared. Publication was in loose-leaf form by the lithoprint process. Five hundred copies of the Plan Service Handbook were printed for first distribution, and five hundred additional have been prepared for sale in limited quantities[2].

Publicity. Several feature articles and a large number of news stories were scheduled. The extension editor outlined a series of 26 planning stories for the first year, each one illustrated by a perspective drawing and floor plan. These articles are released on a schedule in mat form to some fifty small daily and weekly newspapers in the state. Two posters, in three-color printing, were prepared for use in county offices and at meetings. Two letter inserts were prepared to be used in connection with correspondence. Photographs have been obtained to build two strip films, of about 50 frames each, for use in winter meetings.

The author has begun a 12-month series of articles featuring the principal building plans, to be used in a farm magazine that has a wide circulation in the state.

Survey. It was recognized that the best basis on which to project a "home-built" building program was the experience of farmers in the state who had already participated in local demonstrations. A typical selection of about 200 new buildings of various economic levels was made the subject of a survey to indicate the possibilities of such a program. In a general way, the survey indicated that it would be possible to substitute materials and services for as much as two-thirds of the normal cash outlay.

Plan Distribution. It is, of course, desirable that every rural building be constructed from plans that have been worked out for best economy, architecture, and serviceability. At the same time, an enormous waste would occur if plans were distributed in quantity, or indiscriminately. A fundamental policy was adopted which appears to be a satisfactory solution to the distribution problem. Plans desired by extension agents for cooperative demonstration projects are loaned without cost, as necessary supplies, while other plans are furnished only upon payment of the nominal charge to cover printing and mailing. An electric blueprinting machine was purchased to facilitate the making and handling of prints. Eventually each extension agent will be provided with a copy of each principal plan, for office use.

Materials Dealer Cooperation. Since the local dealer or merchant is the familiar point of contact for building material service, the cooperation of the dealers was requested at the outset of the program. Although the program was based primarily on the utilization of home resources, the dealers' association in the state, as well as manufacturers' and trade associations, gave enthusiastic approval to the program, and agreed to participate. Incidentally, each retail lumber dealer in the state has been provided with a copy of the handbook.

Conferences. The educational conferences at the start of the program included a series of preliminary meetings with representatives of the trade, dealers, farm organizations, and experiment station and extension leaders. These conferences were valuable in developing the program, publicity, and procedure. A two-day conference with the supervisory and specialist staff served to familiarize the leaders with the program. Eight district conferences were held to carry the plan to all county and home demonstration agents. Individual staff members held conferences with district dealers, editors, farm organizations, and the state home demonstration camp.

County Contacts. Almost every phase of extension service activity in the state is being used in projecting the home building program. In Arkansas, the "achievement" day meetings, 4-H club, Junior-Adult club, home demonstration club councils, county fairs, and Better Homes week are utilized, in addition to the regular office and field contacts. Copies of the plan service handbook have been placed in each vocational school in the state.

CONCLUSION

The projection of a farm and home building program on a state-wide basis requires careful preparation to assure ample publicity, illustrative materials, dealer cooperation, suitable plans, and preparatory conferences to enlist the full support of the agencies who will participate. The program is far broader than technical architecture or agricultural engineering in its responsibilities.

[2]Price 50 cents, from C. C. Randall, Assistant Director, Agricultural Extension Service, 524 Post Office Building, Little Rock, Arkansas.

The Warming of Milk in Transit

By John E. Nicholas

PRODUCTION of high quality milk has received much attention during the past several years. Nearly every factor which controls or affects the quality of milk has been studied and many improvements made to insure the keeping quality of fresh milk. The sanitary practices which must be observed in and around the barn have been stipulated. Health authorities and dairymen, in cooperation with milk distributors, have agreed upon definite health regulations as applied to herds and attendants. The necessity of immediately cooling milk after it is drawn and the necessity of clean or practically sterile milk utensils have been accepted as prerequisites.

Milk, however, often is transported many miles from the farm to the receiving station, under many different circumstances, and occasionally in extreme summer temperatures, without protection. Milk which has been cooled to below 40 F (degrees Fahrenheit) immediately after being drawn may warm considerably during transportation. To obtain experimental evidence, studies were made on cold fresh milk transported in a truck under conditions approximately similar to those on average Pennsylvania routes.

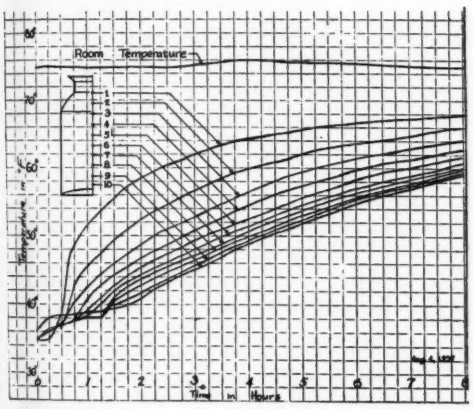
Experimental Procedure. Tests were made in the research laboratory on a 10-gal can of water which had been cooled to below 40 F. The can remained in a relatively constant air temperature for the equivalent number of hours required by a milk transport truck to cover a milk route. Ten thermocouples were used to measure the rise in temperature of the water in the can. These were spaced 2 in apart on a rod which was suspended in the center of the can, the lowest couple being 1 in from the bottom of the can. The rise in temperature of 10 gal of water, placed in an ambient air of 75 F average temperature, is shown in Fig. 1.

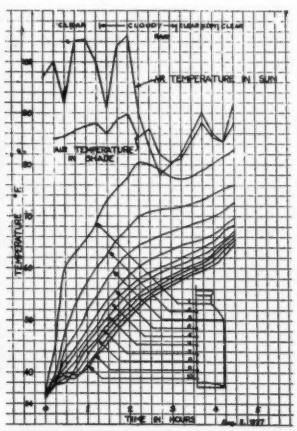
There was a one-degree variation in the room temperature during the test period, a maximum of 76 F and a minimum of 75 F. The initial water temperature was 35.7 F. At the end of the first, second, third, and fourth hours, respectively, the difference between the warmest (top) and coldest (bottom) temperatures in the can was 13.7, 17.4, 16.8, and 15.2 F respectively. This difference decreased with each succeeding hour. The average rise in temperatures for the first and for the second hours was 5.4 F each, or 10.8 F in the first two hours. The average temperature at the end of the fifth hour was 56.6 F, or a total average temperature rise of 20.8 F in 5 hours.

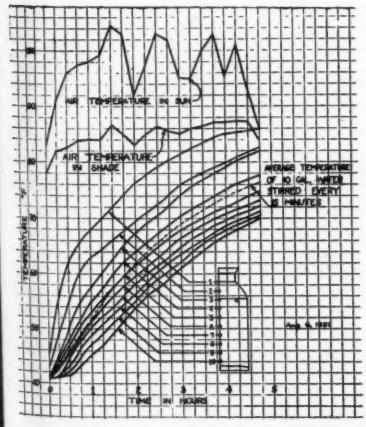
Temperature Rise of 10 Gal of Fresh Milk. Experimental procedure similar to that described was followed with a 10-gal can of fresh milk, which had been cooled to 35.4 F, but was exposed to the outside air in the sun without any protection. The rate of warming of the milk in the can, the air temperature in the shade and in the sun, and the weather conditions are shown in Fig. 2.

Paper No. 797 in the Journal Series of the Pennsylvania Agricultural Experiment Station. Authorized for first publication (November 19, 1937) in AGRICULTURAL ENGINEERING.

Author: Professor of agricultural engineering, The Pennsylvania State College. Mem. ASAE.






AIR TEMPERATURE IN SUN
AIR TEMPERATURE IN SHADE
AVERAGE TEMPERATURE OF 10 GAL WATER STIRRED EVERY 15 MINUTES
TIME IN HOURS

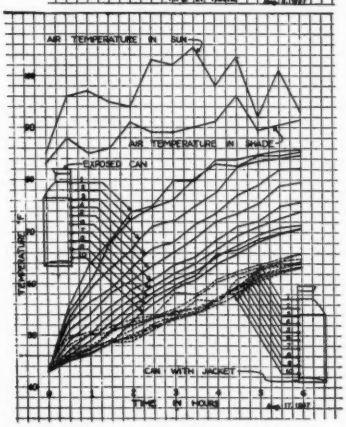


FIG. 1 (UPPER LEFT) RISE IN TEMPERATURE OF 10 GAL OF WATER INITIALLY AT 35 F, WHEN PLACED IN A ROOM TEMPERATURE APPROXIMATELY CONSTANT AT 75 F. FIG. 2 (UPPER RIGHT) RISE IN TEMPERATURE OF 10 GAL OF MILK IN CAN EXPOSED UNPROTECTED TO OUTSIDE AIR AND SUNLIGHT. FIG. 3 (LOWER LEFT) RISE IN TEMPERATURE OF A 10-GAL CAN OF MILK COMPARED TO THE AVERAGE RISE IN TEMPERATURE OF A 10-GAL CAN OF WATER, BOTH INITIALLY AT APPROXIMATELY THE SAME TEMPERATURE AND SIMILARLY EXPOSED IN THE SUN. FIG. 4 (LOWER RIGHT) THE COMPARATIVE TEMPERATURE RISE OF MILK IN TRANSIT FROM THE FARM TO THE RECEIVING STATION IN PROTECTED AND FULLY EXPOSED CANS

The difference between the warmest (top) and the coldest (bottom) milk temperature at the end of the first, second, third, fourth, and fifth hours was 25.0, 26.7, 21.6, 20.1 and 18.3 F, respectively. The average milk temperature rise during the first, second, third, fourth and fifth hours was 13.2, 9.9, 4.7, 3.5, and 2.3 F. An average temperature rise of 23.1 F in the first two hours of exposure and a total average temperature rise of 34.6 F in five hours of exposure was the result.

Milk and Water Compared. To compare the rise in temperature of 10 gal of milk with an equal quantity of water, two cans, one containing cold fresh milk and the other cold water at approximately the same initial temperature, were exposed simultaneously. The milk temperature was measured, as before, by ten thermocouples. The contents of the water can were stirred every 15 min and the average temperature obtained by a standard thermometer. Both cans were similarly exposed without any protection. The rise in temperature of the two cans is shown in Fig. 3. The ten curves refer to the milk and the dotted curve is the average temperature of the 10 gal of water. The air temperatures in the sun and in the shade are also given. Table 1 is tabulated for comparison.

TABLE 1. RISE IN AVERAGE TEMPERATURES OF A CAN OF MILK AND A CAN OF WATER DURING EXPOSURE TO THE OUTSIDE AIR IN THE SUN

Time cans were exposed, hr	Average temperature of can at end of interval, deg F		Difference in temperature in milk between top and bottom at each interval, deg F	Average rise in temperature for each successive hr, deg F	
	Milk	Water		Milk	Water
0	41.3	40.5	0.6		
1	54.1	51.8	22.4	12.8	11.3
2	62.3	62.0	22.5	8.2	10.2
3	68.9	69.0	20.5	6.6	7.0
4	73.6	73.5	18.0	4.7	4.5
4¾	76.0	76.2	16.0	2.4	2.4

The temperature difference in the milk was 22.4, 22.5, and 20.5 F at the end of the first, second, and third hours, respectively. The rise in the average temperature for the first two hours of the milk and the water was 21.0 and 21.5 degrees, respectively. The total rise in the 4.75 hours of milk and water was 34.7 and 35.7 F, respectively. For all practical purposes, the two fluids behaved similarly under identical atmospheric exposures.

Trial Run of Milk Cans in Transit. In order to find the rate of warming of milk while in motion and when exposed to the sun and wind, two 10-gal cans were mounted on the rear of a small truck. To measure the temperatures of the liquid at different levels, thermocouples were used as in preceding tests. A galvanometer and a potentiometer were mounted on the back of the truck. The cans were filled with water at an average temperature of approximately 40 F. The thermocouples were put in place, and over one can a standard milk can insulating cover filled with felt and fiber was placed. An initial reading was taken. The truck was then driven around the countryside. Readings were taken every 30 min, the truck being stopped approximately 10 min every hour. A record was kept of temperatures in the sun and in the shade at the time of reading. This procedure was designed to test the practicability of using the experimental apparatus in transit and to determine its limitations.

This was followed by loading the truck with two cans of milk and driving it over a regular 30-mi milk route. One of the milk cans was covered with the regulation milk can jacket; the other was entirely exposed. Both cans contained fresh milk initially at 43.5 and 43.0 F, respectively. Fig. 4 shows the result of this test. The temperature of the air in the sun and in the shade are given. Readings were taken every 30 min. The time required for stopping, making the necessary adjustments, reading the thermocouples, and the imposed maximum speed limit of 20 mph, because of the delicate instrument carried on the truck during the experiment, are the reasons for the six-hour duration of the test—three hours each to and from the station.

Fig. 4 and Table 2 show that the rise of the average milk temperature in transit on a hot summer day during the first, second, and third hours for the covered and the uncovered cans was 4.1, 3.4, 3.4, and 10.8, 7.8, 5.2 F, respectively. The total rise of the average temperature in the first three hours for the uncovered can was 23.8 F as compared to 10.9 F for the covered can in the same interval.

The difference in milk temperature between the top and bottom of the exposed can was 21.0 F at the end of the second hour and only 3.0 F for the protected milk can.

SUMMARY

1 When a 10-gal can of fresh cold milk (or cold water) was exposed to summer air, the rise in the average milk temperature during the first two hours was 10.5 and 9.3 F per hour (Tables 1 and 2).

2 The difference in temperature between the top and the bottom of the same can of milk was as high as 22.5 F (Table 1).

3 In the fully exposed can, when the average temperature of the milk at the end of the first hour was 53.8 F, the top milk temperature in the same can was 63.9 F (Table 2).

4 The protected can, under similar exposure, showed a rise in the average temperature of but 3.8 F per hour for the first two hours (Table 2).

5 There was a stratification of temperature in the milk can when the can was exposed to the influence of warm atmospheric air. The effect on bacterial growth because of this stratification should be studied.

TABLE 2. COMPARATIVE RISE IN THE AVERAGE TEMPERATURES OF JACKET COVERED AND FULLY EXPOSED MILK CANS IN TRANSIT MEASURED IN HALF-HOUR INTERVALS

Duration of interval in transit, hr.	Average temperature of milk in 10-gal can at end of interval, deg F		Rise in average temperature during each hour in transit, deg F		Temperature difference between top and bottom of can at end of each hour, deg F		Temperature of milk in exposed can at top, deg F
	Covered can	Fully exposed can	Covered can	Fully exposed can	Covered can	Fully exposed can	
0	43.5	43.0			0	0	43.0
0.5	46.7	50.0					
1.0	47.6	53.8	4.1	10.8	4.1	17.5	63.9
1.5	49.6	57.9					
2.0	51.0	61.6	3.4	7.8	3.0	21.0	73.9
2.5	52.8	64.4					
3.0	54.4	66.8	3.4	5.2	4.9	20.8	80.0
3.5	55.6	68.9					
4.0	57.6	72.1	3.2	5.3	4.4	19.9	83.8
4.5	59.8	74.0					
5.0	62.2	75.7	4.6	3.6	2.8	16.6	84.8
5.5	63.3	77.3					
6.0	64.3	78.1	2.1	2.3	2.2	15.1	85.8

(Acknowledgment: The author wishes to acknowledge his indebtedness to Ernest Axman, instructor in electrical engineering and Robert P. Hunter for their patience and care in recording the data for tests under trying hot summer weather conditions.)

Experimental Studies in Terracing

By Dwight D. Smith

RUNOFF and soil loss data from certain of the terracing experiments at the Bethany (Missouri) Soil Conservation Experiment Station will be presented and discussed in this paper.

Terrace Spacing. Six terraces are included in this study. Three are located on a moderate slope of 7 to 8 per cent; the other three on a steep slope of 13 to 14 per cent. These terraces are cropped with a 3-year rotation of corn, oats, and clover with timothy. All farming operations are performed on the contour. Each terrace has a 4-in (per 100 ft) constant grade. The terraces of the moderate-slope group are each 1040 ft long and have vertical spacings of 3, 5, and 7 ft. Those of the steep-slope group are 700 ft in length and have vertical spacings of 5, 7, and 9 ft.

The terrace with the 5-ft vertical spacing of the moderate-slope group may be considered a normal terrace for the Shelby loam region (Table 1). Based on 5-yr data, the rotation average soil loss in runoff for this terrace is 1.42 tons per acre per year. Corn years account for 58.7 per cent of this loss; oats, 36.8 per cent; clover with timothy, 4.5 per cent. The same general tendency is shown for runoff.

Of 5.20 in runoff resulting from an average annual rainfall of 30.5 in, corn years account for 50.2 per cent; oats 35.9 per cent; and clover with timothy 13.9 per cent. In 1932, when in oats, this terrace had a soil loss in runoff of 0.13 tons per acre, but in 1935, a year with almost continuous spring rains, it showed a loss of 3.01 tons of soil per acre, or 23 times as much as the previous oats year. In 1932, oats had a runoff loss of only 5 per cent, while in 1935 the loss was 26 per cent. Clover with timothy has always given relatively low soil and water losses.

Ninety rain periods have caused runoff from this terrace during the past 5 yr. Two of these rains (2.2 per cent) have accounted for nearly half (48.5 per cent) of the total soil loss in runoff. One of these rains came when the ground was plowed for corn, and the other when oats were about 2½ in high. They were the only two soil-loss rains occurring during this five-year period in which the soil loss exceeded 0.50 tons per acre. Five rains occurred in which the soil loss in runoff ranged from 0.25 to 0.50 tons per acre. During this period, one rain of once-in-35-years frequency and two of once-in-5-years frequency (Yarnell's rainfall data) occurred.

For the moderate-slope group, rotation average annual soil losses in runoff increased with an increase in spacing. This relationship existed for the two greatest soil-loss rains previously mentioned. Eliminating the data from these two rains, no definite relationship is shown between spacing and soil loss. This relationship is not true for runoff, the medium spacing showing the highest runoff loss. The condition is noticeable for all rains, although slightly more pronounced for the small-soil-loss rains. The terrace is located on the steepest part of the slope, and therefore should have the shallowest soil, which would account for the high runoff.

Lowest rotation average soil loss in runoff for the steep-slope group is on the medium spacing. The close spacing has an extremely high average slope after terracing (18.6 per cent) which may account in part for the loss being approximately that for the widest spacing. The soil survey shows a larger percentage of pervious soil where the wider spacings are located. This undoubtedly accounts

TABLE 1. TERRACE SPACING STUDIES—ANNUAL SOIL AND WATER LOSSES

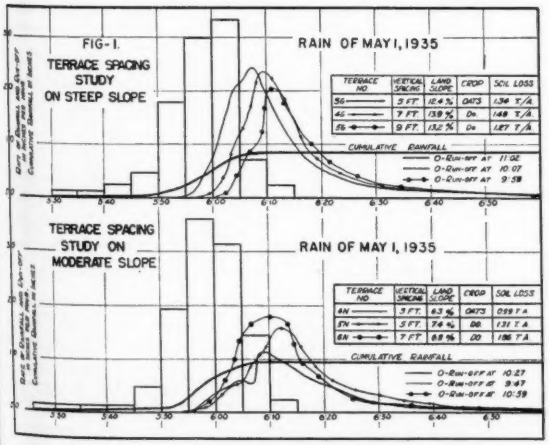
Normal Shelby Loam—Contour Operation
Soil Treatment of Phosphate Fertilizer

			Crop		Runoff					
Year	V. I., ft	Slope, per cent	Kind	Yield*	Rainfall, in	Max rate, in hr	Total, in	Per cent	Density, tons per acre-in	Soil loss in tons per acre
	3	6.3	Oats	62.4	27.36	0.41	2.36	9	0.11	0.25
	5	7.4		59.6	27.36	0.21	1.47	5	0.09	0.13
1932	7	6.8		59.6	27.36	0.40	1.17	4	0.17	0.20
	5	12.4		(	27.84	1.13	2.62	9	0.15	0.39
	7	13.9		(43.9	27.84	0.62	1.87	7	0.25	0.47
	9	13.2		(	27.84	0.46	1.28	5	0.26	0.33
	3	6.3	Cl&T	1.73	31.37	0.26	1.09	4	0.06	0.07
	5	7.4		1.85	31.37	0.50	3.22	10	0.09	0.29
1933	7	6.8		1.85	31.37	0.61	2.24	7	0.07	0.16
	5	12.4		(	32.11		5.47	17	0.04	0.23
	7	13.9		(1.68	32.11	0.89	4.39	14	0.10	0.43
	9	13.2		(	32.11	0.76	3.32	10	0.06	0.21
	3	6.3	Corn	No	31.18	1.50	3.75	12	0.31	1.16
	5	7.4		grain	31.18	2.18	7.84	25	0.32	2.50
1934	7	6.8		har-	31.18	1.76	6.45	21	0.71	4.57
	5	12.4		vest	32.22	3.63	9.36	29	0.34	3.15
	7	13.9			32.22	3.21	9.52	30	0.26	2.52
	9	13.2			32.22	3.02	7.74	24	0.44	3.37
	3	6.3	Oats	31.1	37.27	1.08	5.90	16	0.35	2.07
	5	7.4		39.5	37.43	1.52	9.74	26	0.31	3.01
1935	7	6.8		40.6	37.53	1.78	8.25	22	0.45	3.74
	5	12.4		30.3	36.52	2.40	10.92	30	0.33	3.65
	7	13.9		34.5	36.52	2.36	10.66	29	0.38	4.02
	9	13.2		41.7	36.52	2.01	8.35	23	0.40	3.37
	3	6.3	Cl&T	1.28	24.36	0.67	1.04	4	0.23	0.24
	5	7.4		1.87	24.37	0.34	1.11	5	0.08	0.09
1936	7	6.8		1.49	24.39	0.23	0.85	4	0.01	0.01
	5	12.4		1.26	24.89	0.76	1.25	5	0.01	0.01
	7	13.9		1.57	24.89	0.10	1.35	5		Trace
	9	13.2		2.29	24.89	0.05	1.02	4		Trace
	3	6.3			30.45		2.98	10	0.28	0.83
Rota-	5	7.4			30.48		5.20	17	0.27	1.42
tion	7	6.8			30.75		4.23	14	0.58	2.46
aver-	5	12.4			30.97		6.50	21	0.27	1.78
age	7	13.9			30.97		6.22	20	0.24	1.51
	9	13.2			30.97		4.91	16	0.36	1.78

*Bushels or tons per acre.

Presented before the Soil and Water Conservation Division at the annual meeting of the American Society of Agricultural Engineers at Urbana, Illinois, June 24, 1937.

Author: Associate agricultural engineer, U. S. Soil Conservation Experiment Station at Bethany, Missouri. Mem. ASAE.



for the increase in total runoff with decreased spacing, and probably is a contributing factor to the high soil loss for the close spacing.

While it is true that with a constant original slope and constant soil, some variation in runoff would be expected with different spacings, the density of runoff (tons of soil per acre-inch runoff) is one of the factors to be considered in selecting the most desirable spacing. In Table 1 it will be noted that the density of runoff for the rotation averages does not materially vary between the two closer spacings for the moderate-slope group, but almost doubles for the widest spacing. A smaller variation in density with spacing is noted for the steep-slope group.

Hydrographs of the six spacing terraces are shown in Fig. 1. The rain shown is one which would occur in the locality of the Bethany station once or twice a year. Six other rains have occurred during the period 1931 to 1936 inclusive, which have had equal or greater intensities for 10 and 15-min periods.

Table 1 gives the specifications of these terraces. Soil variation is shown in Table 4.

The slowness with which runoff starts for the wide-spacing terrace (5G) of the steep slope group would indicate a higher rate of infiltration for this area than for the other two areas (3 and 4G). Greater depression storage[1] would also tend to slow up the start of runoff from this area due to a somewhat lesser slope. Soil variations as shown in Table 4 would indicate a higher infiltration rate for the widest-spaced terrace and also the lowest rate for the narrow spacing. The shorter slope of the narrow-spacing terrace probably accounts for its earlier peak.

The variations in length of slope for the terraces of the moderate-slope group are apparently sufficient to cause earlier peaks and reduced rates of runoff for the closer spacings. The middle spacing, which has the steepest slope and consequent reduced depression storage and infiltration rate, has an earlier start of runoff. From a consideration of the soils the widest spacing would be expected to have the lowest infiltration rate and consequently the greater total runoff, and the narrowest spacing would be expected to have the highest infiltration rate and the lowest runoff. The hydrographs indicate this to be true.

From these data, and a consideration of construction and farming costs, it appears that a 5-ft vertical interval is desirable for a moderate slope of about 7 per cent, and an 8-ft vertical interval for a steep slope of about 13 per cent. This allows a 0.5-ft increase in vertical interval for each 1 per cent increase in slope.

Terrace Grades. Six terraces with grades of 8, 6, 4, 2, level, and variable 1 to 4 in fall per 100 ft are included in this study. They are cropped to the same rotation (although one year out of phase) and are handled similarly to the spacing terraces.

The rotation average soil losses in runoff agree very closely with similar terraces of the spacing study (Table 2). A very distinct relationship is shown between soil loss and grade excepting for the 4 and 6-in grade terrace. Channel profiles have shown that these two terraces have undergone a significant change in grade with the different rains

TABLE 2. TERRACE GRADE STUDIES—ANNUAL SOIL AND WATER LOSSES

Normal Shelby Loam—Contour Operation
Soil Treatment of Phosphate Fertilizer

			Crop		Runoff					
Year	Grade, in	Slope, per cent	Kind	Yield*	Rainfall, in	Max rate, in hr	Total, in	Per cent	Density, tons per acre-in	Soil loss in tons per acre
	8	10.9	Corn	27.5	27.36	1.75	3.89	14	1.84	7.17
	6	11.0			27.36	1.21	3.38	12	0.99	3.33
1932	4	11.7			27.36	0.77	3.18	12	0.92	2.91
	2	10.8			27.36	0.50	2.88	11	0.38	0.96
	0	11.1			27.36	0.22	1.47	5	0.43	0.63
	1-4	11.8			27.36	0.81	2.84	10	0.78	2.22
	8	10.9	Oats	61.4	31.37	1.44	4.84	15	0.14	0.66
	6	11.0			31.37	0.87	3.90	12	0.11	0.42
1933	4	11.7			31.37	0.65	4.06	13	0.10	0.42
	2	10.8			31.37	0.37	3.71	12	0.11	0.40
	0	11.1			31.37	0.29	2.56	8	0.08	0.21
	1-4	11.8			31.37	0.21	2.51	8	0.08	0.20
	8	10.9	Cl&T	0.85	31.18	2.40	5.72	18	0.17	0.99
	6	11.0		0.83	31.18	1.96	5.50	18	0.09	0.52
1934	4	11.7		0.96	31.18	2.13	4.03	13	0.17	0.69
	2	10.8		0.83	31.18	1.41	4.51	14	0.06	0.29
	0	11.1		0.99	31.18	0.75	2.96	9	0.09	0.28
	1-4	11.8		1.09	31.18	1.68	2.71	9	0.14	0.39
	8	10.9	Corn	8.0	36.07	2.49	12.33	34	1.18	14.60
	6	11.0			36.07	2.04	10.32	29	0.48	4.93
1935	4	11.7			36.07	1.96	9.42	26	0.59	5.59
	2	10.8			36.07	1.54	9.74	27	0.32	3.14
	0	11.1			36.07	1.02	9.11	25	0.29	2.65
	1-4	11.8			36.07	2.23	10.44	29	0.50	5.27
	8	10.9	Oats	58.5	24.28	0.48	4.07	17	0.13	0.52
	6	11.0		48.6	24.28	0.54	3.08	13	0.06	0.18
1936	4	11.7		67.8	24.28	0.49	2.56	11	0.06	0.16
	2	10.8		65.2	24.28	0.25	2.21	9	0.02	0.05
	0	11.1		54.6	24.28	0.37	1.70	7	0.02	0.04
	1-4	11.8		51.1	24.28	0.23	1.62	8	0.04	0.06
	8	10.9			30.24		6.10	20	0.68	4.15
Rotation	6	11.0			30.24		5.28	17	0.31	1.65
average	4	11.7			30.24		4.55	15	0.38	1.74
	2	10.8			30.24		4.59	15	0.19	.86
	0	11.1			30.24		3.46	11	0.20	.68
	1-4	11.8			30.24		3.81	13	0.37	1.42

*Bushels or tons per acre.

[1] "Hydrologic Interrelations of Water and Soils," by Robert E. Horton, American Society of Agronomy, November 1936, and "Surface Runoff Control," by Robert E. Horton, Upstream Conference, September 1936.

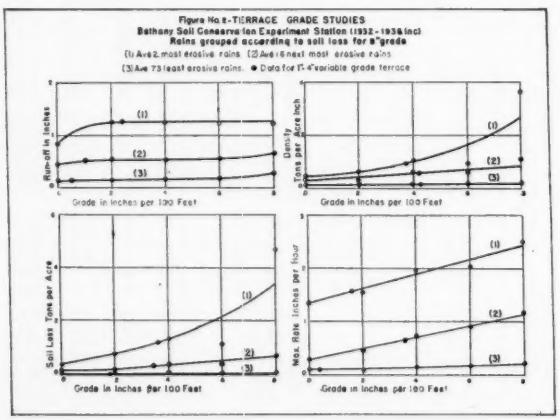
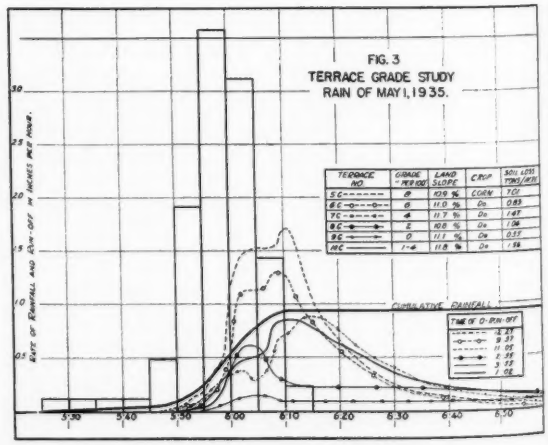
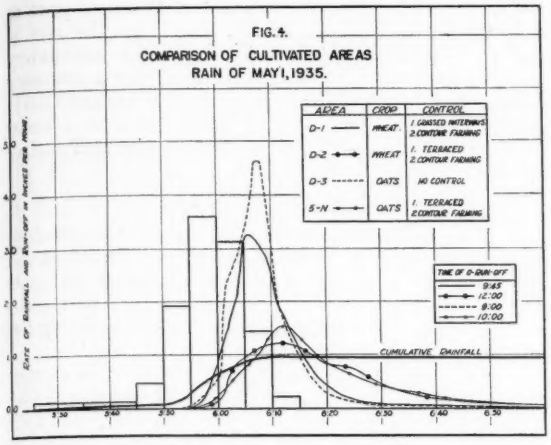
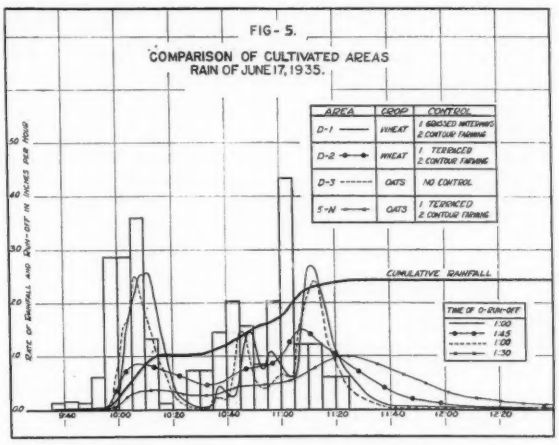


Figure No. 2—TERRACE GRADE STUDIES
Bethany Soil Conservation Experiment Station (1932-1936 inc)
Rains grouped according to soil loss for 8"grade
(1) Ave 2 most erosive rains. (2) Ave 6 next most erosive rains
(3) Ave 73 least erosive rains. • Data for 1-4" variable grade terrace
Run-off in Inches
Grade in Inches per 100 Feet
Soil Loss Tons per Acre
Max. Rate Inches per Hour







and farming operations. The 4-in grade terrace has become steeper toward the outlet and the 6-in grade terrace has become flatter toward the outlet. The grades of the two approximated 5 in fall per 100 ft toward the outlet in the fall of 1936.

Ninety-one runoff rains have occurred during the past 5 yr for the 8-in grade terrace. These rains were divided into groups according to soil loss. The first group (Fig. 2) consisted of two rains which accounted for 38.8 per cent of the total soil loss. The second group consisted of 16 rains which accounted for 45.1 per cent of the total soil loss, and the third group consisted of 75 rains (80 per cent) which accounted for 16.1 per cent of the total soil loss.

The soil loss in runoff per rain increased rapidly with increased grade for the two largest soil loss rains. As the soil loss per rain decreased, grade became a less important factor (Fig. 2). The variable grade terrace (average grade 2½ in) had a soil loss medium in amount between the 2 and 4-in graded terraces, although greater than the interpolated amount for a 2½-in grade. The level terrace did not have quite as great a soil loss for the two most erosive rains as the 8-in graded terrace had for the group 2 rains.

Grades of 2 in and over do not appear to affect the total runoff for the more erosive rains, although as the erosiveness of the rains decreases, a small relationship appears to develop.

The variable-grade terrace functions more nearly as a level or 2-in grade terrace as the erosiveness of the rains decreases.

Apparently during the more erosive rains, the runoff water has sufficient velocity to smooth or level out any soil washed into the channel of the graded terraces. This prevents ponding. As the amount and maximum rate of runoff decrease, greater reduction in the amount of runoff with reduction in grade is noticeable. The indications are that for the smaller soil loss rains, the velocity of flow in the channels of the flatter grade terraces is not sufficient to smooth out any fans and prevent ponding.

Studies by Musgrave[2] show a very low infiltration rate for this soil type. The increased time the runoff is on the field due to the flatter grades does not appear to be sufficient to account for more than a very small part of the decrease in the total runoff. Observation indicates that the reduction in runoff for the flatter grades is due to ponding.

TABLE 3. SOILS OF AREAS SHOWN ON HYDROGRAPHS

Percentages are Approximate

Area	Shelby loam, 9 to 12 in, per cent	Shelby loam, 4 to 7 in, per cent	Colluvial material, per cent	Shelby clay, per cent	Disturbed area, per cent
4N	95		2		3
5N	75	11	8		6
6N	37	34	18		11
3G	75	18		7	
4G	82	11	7		
5G	53		47		
5C	63	37	Trace		
6C	44	50	6		
7C	48	44	8		
8C	55	22	23		Grundy silt loam, 8 to 14 in
9C	52	13	35		
10C	44	10	46		
D1	19	39	28	3	11
D2	33	42	13	4	8
D3	60	13	7		20

The average maximum rates of runoff for the different rain groups when plotted against grade show a straight-line relationship, with nearly equal slope for the two greater soil loss groups, although the intercept for the group one rains was several times greater than for the group two rains. As soil losses increase at an accelerating rate with increase in grade, they will increase similarly for maximum rate of runoff (Fig. 2).

Hydrographs of the grade study terraces are shown in Fig. 3. The hydrographs show an appreciable decrease in rate of runoff, with decreased grade, and also indicate a reduction in total runoff and a delayed peak with reduced grade. Surface detention appears to increase with decreased grade, which is to be expected[1] with the lower velocity of discharge from the flatter grades.

Scouring is noticeable at the lower end of the 8-in grade terrace after the more severe rains. From a runoff and soil loss standpoint, the lower grades are the more desirable. Due to delay in farming operations and crop damage caused by ponds in the channel, grades below 2 in do not appear to be practical for the general condition of the Shelby loam region, excepting on the ridges which have the deeper surface soil. The 2 to 4-in variable grade appears the most desirable grade for the general conditions of the region.

Contouring on Terraces. Contouring of corn on terraces gave a soil loss of 56 per cent, and a water loss of 80 per cent, of that for corn checkrowed over terraces for

[2] "Infiltration Capacity of Soils in Relation to Control of Surface Runoff and Erosion," by G. W. Musgrave, Journal, American Society of Agronomy, May 1935.

the six-month period, July 1 to December 31, 1931. These figures were adjusted from ratios secured in 1934 when both fields were in corn on the contour, as the degree of slope of the two fields is not the same.

Terrace Maintenance and Cross Section. Very little maintenance has been necessary on the 8.3 mi of experimental terraces on the Bethany station, when once the terrace had been constructed to proper size. Average maintenance time over a 5-yr period has been 5.9 man-hours and 2.8 tractor and grader-hours per mile per year. Factors effecting maintenance appeared to be original depth of surface soil, rotation, slope, spacing, and grade. Sufficient data is not available to show the relative importance of these factors.

All plowing of terrace areas during the last 3 yr has been done with a two-way plow, always turning the furrow slice up hill and leaving the only dead furrow between terraces in the terrace channel. In the fall of 1936, 2 mi of terraces plowed by this method were raised from an average difference in elevation of terrace channel and ridge of 1.06 ft, to 1.67 ft. These same terraces after disking, harrowing, and planting to corn the next spring, were reduced to an average height of 1.29 ft. Cross-section reading before plowing showed an average channel area of 11.5 sq ft. This area was increased to 19.0 sq ft after plowing, and reduced to 13.1 sq ft after disking, harrowing, and planting to corn the following spring. All farming operations on these terraces involving the movement of soil are on the contour.

Runoff Hydrographs from Small Cultivated Watersheds. Figs. 4 and 5 show hydrograph records from areas D-1, D-2, D-3 and 5-N on the Bethany station. D-2 is an 8.0-acre terraced field of 7.0 per cent slope. The measuring equipment is located at the lower end of a grassed outlet channel which received the runoff from the 8 terraces of the area. D-1 is a 7.5-acre watershed of 6.5 per cent slope. It is farmed on the contour, and has grassed waterways. Soil treatment and rotation are identical on D-1 and D-2. D-3 is a 4.5-acre watershed of 6.7 per cent slope. Farming operations are with the field boundaries. The waterway is plowed and cultivated with the remainder of the field. Area 5-N is a single terrace; its specifications are given in Table 1. The variation of soils on these areas is shown in Table 3.

Similarity between the hydrograph of area D-2 and 5-N for the rain of May 1 is very noticeable, despite the fact that one is a single terrace and the other a terraced watershed. The similarity is not so pronounced for the rain of June 17, although the variation is not as great as that with the hydrographs of D-1 and D-3. The rain of May 1 is the same as discussed under the sub-heading "Terrace Spacing." The rain of June 17 has a frequency of occurrence of once-in-5-years (Yarnell's Rainfall Data). Reduction in the peak rate of runoff without material reduction in total runoff would indicate increased surface detention for areas D-2 and 5-N.

CONCLUSIONS

1 The major soil loss in runoff from terraced land occurs when the area is without vegetative protection.

2 Of a 5-yr average soil loss in runoff of 1.42 tons per acre, 58.7 per cent was during the corn year, 36.8 per cent during the oats year, and 4.5 per cent during the clover with timothy year (3-yr rotation).

3 Of a 5-yr average runoff of 5.2 in from an average annual rainfall of 30.5 in, 50.2 per cent was during the corn year, 35.9 per cent during the oats year, and 13.9 per cent during the clover with timothy year.

4 Soil loss in runoff, and runoff, is nearly always high for corn, low for clover with timothy, and high or low for oats, depending upon the season.

5 Two rains in a 5-yr period accounted for nearly half of the total soil loss in runoff.

6 A vertical interval of 5 ft is desirable for a 7 per cent slope on normal Shelby loam.

7 A vertical interval of 8 ft is desirable for a 13 per cent slope on normal Shelby loam.

8 Terrace grades above 4 to 6 in fall per 100 ft are undesirable from an erosion standpoint.

9 Terrace grades below 2 in fall per 100 ft are undesirable due to ponds in the channels.

10 Variable grade of 2-4-in fall per 100 ft is desirable for the general condition of the Shelby loam region.

11 Soil loss in runoff was 56 per cent and runoff 80 per cent for contoured corn, in comparison with check-rowed corn on terraces.

12 Five-year average annual maintenance on 8.3 mi of terraces has been 5.9 man-hours and 2.8 tractor and grader-hours per mile.

13 Plowing terraces uphill with a two-way plow increased their height 57 per cent.

14 Disking, harrowing and planting to corn reduced the terrace height 23 per cent from height after plowing.

15 Terraces materially reduced the peak rate of runoff during erosive storms on small cultivated watersheds.

16 Terraces increase the surface detention during excessive runoff periods.

Factors in Rural Electric Service

A PAPER on the above subject, dealing particularly with rural electrification problems from the public utility viewpoint, was presented before the Rural Electric Division at the annual meeting of the American Society of Agricultural Engineers, at Urbana, Illinois, June 22, 1937, by I. L. Craig of the Philadelphia Electric Company. Due to its length, special field of interest, and the fact that mimeograph copies are available, it will not be published in AGRICULTURAL ENGINEERING.

Specifically, this paper deals with the inception of the Pennsylvania rural electric service plan, definition of rural electrification from the utility viewpoint, expansion of service area, built-up versus lean-area service, social aspects of the rural problem, community partnership arguments, municipal plant development, haphazard plans of service extensions, early regulation, rate principles magnified by rural services, distribution costs, high costs per kilowatt-hour, Pennsylvania's General Order 27 and the distance charge plan, customer's viewpoint on service, guarantee of revenue as a substitute for the distance charge, salability of the plan, joint recommendations to the Commission, General Order No. 28 of the Public Service Commission, the guarantee plan, no supply construction investment by the customer, credit protection on loan extensions, stability of the plan-contract term, repudiation of plan by customers, Rural Electrification Administration, customer's equipment for use of service, utilities pressed for extensions, and development of rural electric use.

Interested members of ASAE, who have not already received a copy, will be furnished one without charge on request to the editor.

Distillate as a Tractor Fuel

By E. L. Barger and J. L. Gale

MANY TRACTOR owners have burned distillate for years with success. Others have reported only fairly satisfactory performance, and a considerable number have had generally unsatisfactory results. The fact that distillates on the market vary in quality has been a matter of common knowledge to those concerned with tractors and tractor fuels, and it has generally been ascribed as the cause for the nonuniform results obtained when using this fuel.

Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, Illinois, November 30, 1937. Contribution No. 84 from the department of agricultural engineering, Kansas State College.

Authors: Respectively, assistant professor of agricultural engineering, Kansas State College, (Mem. ASAE), and formerly graduate assistant in agricultural engineering, Kansas State College.

TABLE 1. SUMMARY OF DISTILLATION TESTS OF DISTILLATES AND KEROSENES

Kind of fuel	Distillates, 32 samples			Kerosene, 8 samples
Data shown	Average distillation temperature, F	Maximum distillation temperature, F	Minimum distillation temperature, F	Average distillation temperature, F
Initial point	333	400	250	306
5%	391	450	344	—
10%	399	466	358	371
20%	416	479	379	388
30%	429	490	395	403
40%	439	499	402	415
50%	450	507	409	427
60%	460	522	416	439
70%	471	542	425	451
80%	485	562	438	465
90%	506	589	460	485
95%	527	617	476	502
End point	543	642	497	512
Recovery, per cent	97.9	—	—	97.88
Distillation loss, per cent	0.6	—	—	0.85
Residue, per cent	1.5	—	—	1.26

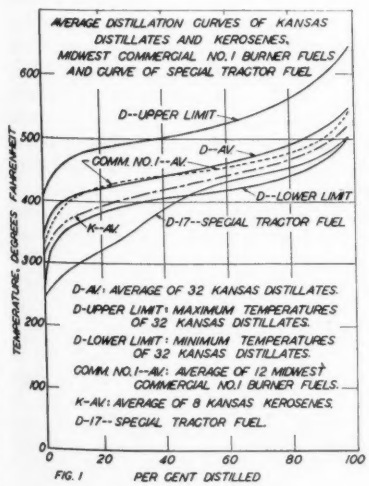
One of the objectives of a project on tractor fuels in the Kansas Engineering Experiment Station has been to obtain information on distillates used in tractors in the state and determine, if possible, what the characteristics of a satisfactory distillate should be. This work has been carried on over a period of six years, and a major part of the data obtained is presented in this paper.

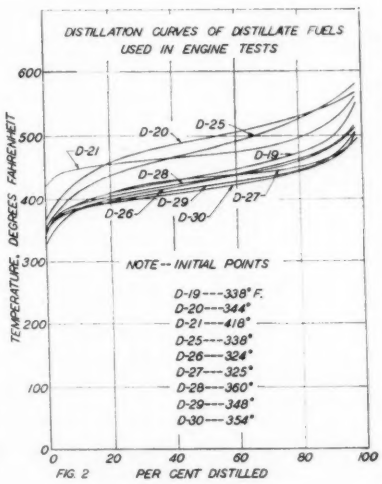
Low cost and high heat content per gallon are unquestionably the attractive features of distillates as a fuel for low-compression, spark-ignition tractors. These can be combined into one factor, namely, low cost energy.

With the present price differential between distillate and the various grades of gasoline, the purchaser receives for his money from 60 to 100 per cent more Btu in the distillate. This is, and should be, an attractive feature to the tractor owner if, in other respects, it is a generally satisfactory fuel.

The variable nature of some of the distillates from the standpoint of distillation tests is summarized in Table 1 and Fig. 1. The average distillation range of thirty-two distillates purchased in Kansas was found to be between 333 and 543 F (degrees Fahrenheit). This agrees quite closely with the average of twelve samples of commercial No. 1 burner oils from midwest sources as reported by Mendius, Ainslee, and Scalesman[1]. The average curve for these fuel oils is shown in the dotted line in Fig. 1. It should be pointed out that these so-called No. 1 burner oils would generally be sold as tractor distillates. The range in temperatures at any point in the distillation curves for thirty-two distillates is approximately 100 F with the exception of the initial points where the range is 150 F, varying all the way from 250 to 400 F. The variation in end points was found to be 145 F.

The average distillation curve of eight kerosenes is shown in Fig. 1 for a basis of comparison. It will be seen that some of the distillates of lower distillation range fall below the kerosene curve. The D-17 curve is a special tractor fuel with a 45.9 API gravity, made in a Kansas refinery but not sold in Kansas because of tax regulations. It is shipped to a neighboring state.


AVERAGE DISTILLATION CURVES OF KANSAS DISTILLATES AND KEROSENES, MIDWEST COMMERCIAL NO. 1 BURNER FUELS AND CURVE OF SPECIAL TRACTOR FUEL
D--UPPER LIMIT
D--AV.
COMM. NO. 1--AV.
D--LOWER LIMIT
K--AV.
D-17--SPECIAL TRACTOR FUEL
D-AV: AVERAGE OF 32 KANSAS DISTILLATES.
D-UPPER LIMIT: MAXIMUM TEMPERATURES OF 32 KANSAS DISTILLATES.
D-LOWER LIMIT: MINIMUM TEMPERATURES OF 32 KANSAS DISTILLATES.
COMM. NO. 1--AV.: AVERAGE OF 12 MIDWEST† COMMERCIAL NO. 1 BURNER FUELS.
K-AV.: AVERAGE OF 8 KANSAS KEROSENES.
D-17--SPECIAL TRACTOR FUEL.
TEMPERATURE, DEGREES FAHRENHEIT
PER CENT DISTILLED
FIG. 1



The distillation curves shown in Fig. 2 are of nine distillate fuels used in engine tests which will be discussed later. All of these are commercially available except D-21, which was made up of 100 per cent cracked stock and was obtained as a special from the refinery as a check sample.

Table 2 shows the physical analysis of thirty distillates. Note the column headed "Composition." In the conventional operation of a refinery a fraction in the tractor distillate range may be obtained by two methods or from two sources. One is by straight distillation of the crude oil and the other by redistilling a heavy oil fraction after it

[1]Mendius, W., Ainslee, W., and Scalesman, C. H., Petroleum refiner's view of development of high speed Diesel engine fuel. Oil and Gas Journal, 34:76-80. November 14, 1935.

TABLE 2. PHYSICAL ANALYSIS OF DISTILLATES FROM KANSAS REFINERIES

Sample No.	API gravity at 60 F	Weight per gal, lb	Heat value per lb, high, Btu	Composition Straight-run, per cent	Composition Cracked, per cent	Color, Saybolt No.	Octane No.	Sulphur, per cent	Gum, mg per 100 cc
D-2	40.4	6.854	19,600	—	—	—16	17.0	—	—
D-8	42.8	6.759	19,462	—	—	+ 2	6.0	0.133	—
D-9	40.9	6.834	19,499	—	—	+ 7	5.0	0.171	—
D-10	38.5	6.930	19,304	—	—	—16	35.0	0.246	—
D-11	39.5	6.890	19,414	—	—	Darker —16	31.0	0.201	—
D-12	39.7	6.882	19,451	—	—	—	6.0	0.206	—
D-14	44.0	6.713	19,481	—	—	Dyed	1.0	0.197	—
*D-15	30.1	7.291	19,179	0	100	Darker —16	33.0	0.213	—
D-16	38.7	6.922	19,307	100	0	+15	—	0.149	—
*D-17	45.9	6.641	19,218	—	—	—	—	0.191	—
D-18	42.7	6.763	19,478	—	—	—	—	0.207	—
D-19	40.1	6.866	19,685	54	46	Darker —16	23.0	0.085	792
D-20	39.7	6.882	19,494	100	0	+16	—7.0	0.045	181
*D-21	32.0	7.206	19,200	0	100	Darker —16	43.0	0.280	2100
D-22	41.5	6.810	19,695	100	0	Dyed	—7.0	0.058	—
D-23	39.7	6.882	19,426	100	0	+23	—7.0	0.098	—
D-24	40.9	6.834	19,354	100	0	+26	—6.0	0.167	—
D-25	40.3	6.858	19,455	100	0	+20	0	0.072	196
D-26	43.4	6.736	19,383	100	0	+30	3.5	0.150	154
D-27	37.8	6.960	19,234	0	100	Darker —16	39.0	0.176	766
D-28	39.6	6.886	19,355	40	60	—11	30.5	0.100	302
D-29	39.4	6.894	19,649	30	70	Darker —16	33.5	0.180	299
D-30	40.0	6.870	19,231	15	85	Darker —16	34.5	0.078	288
D-31	39.1	6.906	19,405	—	—	Darker —16	35.6	—	420
D-32	40.0	6.870	20,215	—	—	— 9	8.3	—	57
D-33	41.5	6.810	19,537	—	—	+ 6	8.8	—	140
D-34	39.7	6.882	19,731	100	0	— 1	10.3	—	522
D-35	42.9	6.756	19,733	—	—	Dyed	7.8	—	48
D-36	41.4	6.814	19,623	80	20	— 5	19.3	—	110
D-37	42.7	6.763	19,824	100	0	+13	12.5	—	70
Av.	40.6	6.849	19,519	—	—	—	13.6	0.143	290

*Not commercially available, not included in averages.

has passed through the cracking still. This cracked distillate is suitable for tractor fuel, but refinery practice, with few exceptions, is to blend it with straight-run distillate before shipment. The exact proportion depends upon the stocks on hand and the demand for each type, although a given refinery will hold fairly closely to a proportion that has proved satisfactory in service.

Some small refineries which do not have cracking equipment, produce only a straight-run product. Therefore, the tractor distillates available may be either straight-run products, mixtures of straight-run and cracked distillates in varying proportions, or, in exceptional cases, 100 per cent cracked product.

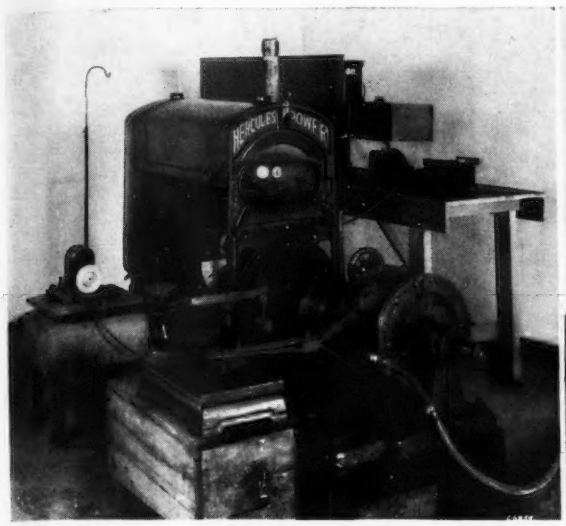
Nash and Howes[2] state that "Generally straight-run spirits have lower anti-knock ratings than cracked spirits from the same crude oil." This statement is well borne out by Table 2. It may be seen that of the seventeen distillates of known composition, the eight which contain no cracked stock (100 per cent straight-run products) had octane ratings from —7 up to 12.5 with an average of slightly less than 0, which is very low indeed. On the other hand, one fuel made up of 20 per cent cracked fuel had an octane number of 19.3; a 46 per cent cracked fuel had an octane number of 23; one of approximately 60 per cent cracked fuel, an octane rating of 30.5; a 70 per cent cracked fuel, a rating of 33.5; an 85 per cent cracked distillate rated 34.5; and finally, three 100 per cent cracked fuels had octane ratings of from 33 to 44 and averaged 38.5. In other words, the octane rating of a distillate fuel from similar crude stock is practically directly proportional to the percentage of cracked fuel used in its make-up.

The natural color of a distillate is a fairly reliable indicator of the composition and therefore of the approximate octane rating of a fresh distillate fuel. Clear or water-white hydrocarbon fuels will "go off color" when kept in storage an appreciable length of time. The change to an amber or straw color will be hastened if the fuel is subjected to sunlight. Ordinarily the distillate fuels are not exposed to light and they are marketed too promptly to permit noticeable discoloration to take place because of these factors.

Table 2 shows that of five low-octane fuels with octane numbers ranging from —7 up to 3.5, the Saybolt color rating was between +16 and +30, or from a prime white to a water white. A 5-octane number fuel had a Saybolt color of +7, and a 6-octane fuel a Saybolt number of +2, both of which would come under a standard white color. Two 12.5 and 8.8 octane fuels had +13 and +6 Saybolt colors, respectively, and would be of a standard white color. Of the ten higher octane fuels, with a range of from 23 to 43 octane numbers, one had a Saybolt color of —11, one a color of —16, and the remaining eight were darker than —16. A —11 color is a faint straw and all the others were, of course, darker in color.

It should be noted that three low-octane fuels (D-14, D-22 and D-35) were artificially colored. Two of these were dyed to simulate a fuel of cracked composition. In these particular instances this could be detected by a trained observer but the average tractor operator would not be able to do so.

[2]Nash, A. W. and Howes, D. A., The Principles of motor fuel preparation and application. John Wiley, New York. 2 v. 1935.



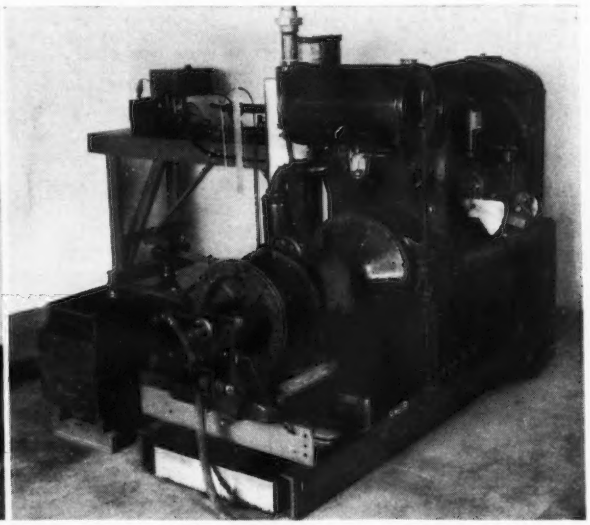


FIG. 3 (LEFT) HERCULES MODEL "OOC" POWER UNIT AND EQUIPMENT USED IN THE FIRST SERIES OF PERFORMANCE TESTS ON DISTILLATE. FIG. 4 (RIGHT) MC CORMICK-DEERING MODEL "P-200" POWER UNIT AND EQUIPMENT USED IN THE SECOND SERIES OF PERFORMANCE TESTS ON DISTILLATE

Table 2 shows therefore that a distillate purchaser in Kansas can be reasonably certain of getting a satisfactory distillate if he judges merely by its color. The only exceptions found to this statement were the above cases of artificial coloring. It may be added that a few states require by law a −16 color for tractor distillates, and demand that the color, if not natural, be obtained artificially. It is known that one very reputable oil company now dyes its tractor distillate a green color to identify its product, but this is justifiable in that the purpose of dyeing is not one of deception. It is this company's intention to maintain its tractor distillate at an octane rating of approximately 35, which is very good.

An examination of Table 2 for sulphur content of distillates sold for tractor fuels shows a range of from 0.045 to 0.246 per cent and an average sulphur content of 0.143 per cent. Generally, cracked distillates show a higher sulphur content than straight-run distillates, but when made from midcontinent crude oils with low sulphur content, there seems to be little danger of excessive amounts of sulphur in the refined product, even when it is cracked. An average sulphur content of 0.143 per cent may be considered safe, so far as danger of corrosion is concerned, especially if the proper precautions are taken for the successful operation of the tractor on distillate. It seems reasonable to assume that the total sulphur in a distillate can safely be somewhat higher than that allowed in gasolines since a large proportion of the distillate used as a tractor fuel is burned in the warmer months of the year and also in view of the fact that the successful use of this fuel requires much closer attention to engine temperatures, with a lesser tendency for water vapor to condense in the crankcase or exhaust pipe. Without the accumulation of water, the corrosive action of the sulphur compounds should be negligible. Three 100 per cent cracked distillates averaged 0.223 per cent sulphur, while seven 100 per cent straight-run fuels averaged 0.105 per cent sulphur.

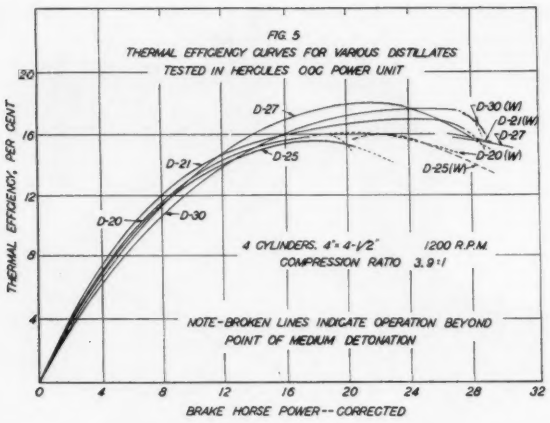
The question of gum in tractor distillates has not received a lot of attention, but there is no doubt in the author's mind that if the proposed requirements of octane ratings as high as 40 are placed on distillate fuels, and assuming that the use of cracked fuels is the method considered to obtain this rating, the gum problem will make itself known. The results of gum tests reported in the last column of Table 2 were obtained by evaporation over a steam bath in a copper dish. To hasten the evaporation, the samples were diluted with three parts of white gasoline and from this the gum in milligrams per 100 cubic centimeters was calculated. Several samples of undiluted distillate were also evaporated as checks. This of course is a long, drawnout process. The copper dish method of gum determinations has little to recommend it. The time element and catalytic action of the copper tend to give higher values than other methods of gum determination, none of which are standard methods for use with fuels of low volatility.

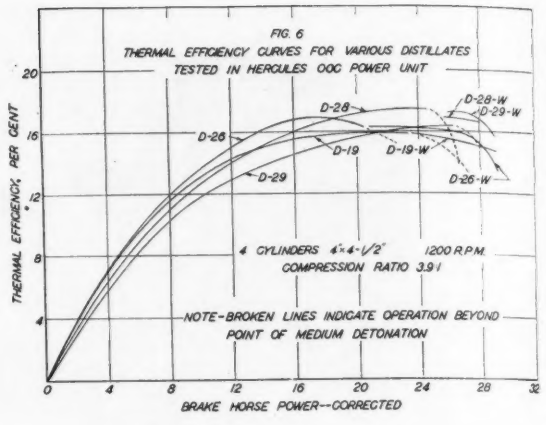
Since it is probably the actual gum present and not the potential gum (that which would develop upon prolonged storage or other conditions favorable to oxidation) that would cause trouble in the engine, it is certain that the copper dish method gives results higher than would be comparable with engine operating conditions. This method gives results which probably more nearly represent the potential gum-forming properties of the fuel. Nevertheless it will serve as a basis of comparison.

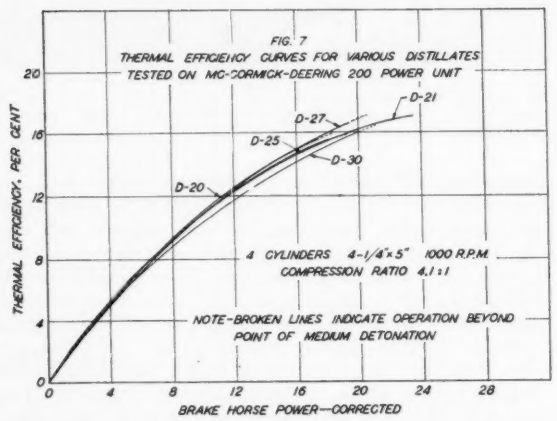
It will be seen that the higher gum content fuels are largely the high octane fuels and also those containing higher percentages of the cracked stock. Seven of the fuels above an octane rating of 20 have an average gum content of 709 mg per 100 cc, while nine fuels below that rating have an average of 164 mg per 100 cc of fuel.

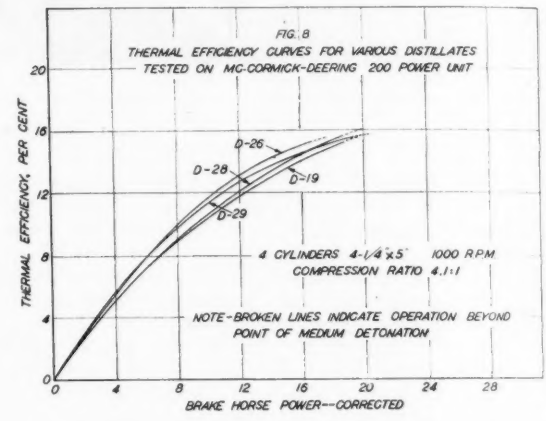
Performance tests were run on nine of the test distillates in two engines. A Hercules "OOC" power unit, illustrated in Fig. 3, was used in the first series of performance tests. The engine is a four-cylinder, L-head type with a 4-in bore and $4\frac{1}{2}$-in stroke. The head used gave the engine a compression ratio of 3.90 to 1. Rated speed is 1200 rpm. A hot, nonadjustable, kerosene manifold was fitted to insure vaporization of the heavy distillate fuels.

For the second series of tests a McCormick-Deering No. 200 power unit was used. This unit equipped for









test purposes is shown in Fig. 4. The engine is a four-cylinder, valve-in-head design with a bore and stroke of 4¼ by 5 in, respectively, and a compression ratio of 4.1 to 1. The rated speed is 1000 rpm. The manifold is of the adjustable type. All tests were made with the manifold set in the kerosene or hot position.

The power output was measured with a Detroit hydraulic dynamometer connected directly to the engines through a flexible coupling.

Engine speed was taken throughout the length of tests with a solenoid-actuated revolution counter driven from the end of the dynamometer shaft. Time was measured with a stopwatch magnetically started and stopped at the same instant as the revolution counter. This was accomplished by a switch fastened to the rotating element of the three-way fuel valve. At the instant of change-over to the test fuels, the switch completed the revolution-counter and stopwatch circuits, and at the end of the test run the reverse action took place.

Temperatures of the cooling water at the top of the radiator were maintained at 190 ± 2 F in the Hercules engine and at from 209 to 210 F in the McCormick-Deering. Maximum carburetor settings were used in all tests. Test runs were 20 min long, with the exception of those loads causing bad detonation, in which case the runs were shortened to 10 min.

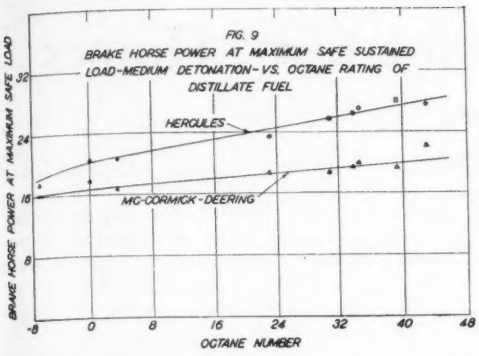
The tests included 196 separate runs and the tables of results are too voluminous to include in this paper. Curves showing the thermal efficiency of the nine test fuels in the two engines are shown in Figs. 5 to 8, inclusive.

A fairly close correlation exists between the thermal efficiency and the octane rating of a distillate at the heavier loads, at which point detonation becomes a limiting factor as regards thermal efficiency. The higher octane fuels detonate less at the heavier loads and therefore maintain a relatively higher efficiency compared with the low-octane distillates.

At low loads, however, there is an apparent tendency for the lower octane fuels to show a higher thermal efficiency than the higher octane fuels. The explanation for this may probably be that the very properties which promote detonation at heavy loads cause relatively complete combustion and higher temperatures at the lighter loads. On this theory the low-octane fuels would tend to give better performance at the lighter loads; however, it is performance with heavy loads which is of major importance in tractor operation.

A study of Figs. 5 to 8, inclusive, indicate no significant correlation between the thermal efficiency of a distillate fuel and its distillation range, although there seems to be some tendency for the fuels of lower boiling range to produce a higher thermal efficiency. This is noticeable in the case of D-26 which has a lower than average distillation range and an unusually high gravity for a distillate (43.4 API).

The remarks made above in respect to the correlation of the thermal efficiency and the octane rating of a distillate are equally valid regarding the relationship between specific fuel consumption and octane rating. The reason for this exceedingly close connection between thermal effi-



ciency and specific fuel consumption lies in the fact that the range in higher heating values is practically negligible. For the nine test fuels the higher heating values varied between 19,200 and 19,685 Btu per pound, or only 2½ per cent.

The relationship between brake horsepower at maximum safe sustained load (medium detonation) and the octane rating of a distillate fuel is quite definite as may be seen by Fig. 9. For both the Hercules and the McCormick-Deering engines there is a fairly direct relation, that is, the higher the octane number, the greater the maximum safe sustained load. From the curve for the Hercules engine it should be noted that while the engine could turn out 27.4 bhp on a 40-octane distillate, its output using an 0-octane fuel was only 20.4 bhp, a power reduction of 25.5 per cent. For the McCormick-Deering the curve indicates that the power output with fuels of the same two octane ratings would be 19.9 bhp and 16.8 bhp respectively, a reduction of 15.5 per cent.

Wilson and Barnard[3], extrapolating data obtained by the U. S. Bureau of Standards, show that the realizable brake mean effective pressure for a 40-octane fuel should be about 98 lb per sq in and for a 0-octane fuel about 69 lb per sq in. The reduction in mean effective pressure, and hence in power output, should be approximately 29 per cent. Therefore, the power reductions found on the Hercules and McCormick-Deering are, if anything, on the conservative side.

This appreciable reduction in maximum safe sustained power output when using low octane fuel is a serious limitation for several important reasons. The tractor operator usually wants to load his tractor up as much as is safely possible, both for economy and improved timeliness of operation. Then, too, on heavy jobs the likelihood of being stalled is considerably increased, due to the lessened reserve power. Another reason, previously brought out, is that the specific fuel consumption at maximum safe sustained load is usually slightly higher for low octane distillate fuels than for the high octane fuels. It may safely be concluded, therefore, that in general the higher the octane rating of a distillate fuel, the more satisfactory is the overall performance.

Carburetor settings for the nine distillates were quite uniform on a given engine. On the Hercules the setting varied from 720 to 785 deg opening of the needle valve, or about 9 per cent, and on the McCormick-Deering the range was from 540 to 560 deg, or about 4 per cent.

Spark settings for maximum load were somewhat more variable. When no water was injected in the Hercules engine, the spark advance was between 16 and 18 deg; with water injection, between 18 and 24 deg. On the McCormick-Deering the range was from 16 to 26 deg without water injection, and from 20 to 26 deg with water. The higher octane fuels permitted the greater spark advance.

The use of water as an antidetonant and its effect on detonation, maximum safe sustained load, and thermal efficiency was investigated. Figs. 5 and 6 show the effect of water injected into the intake manifold on thermal efficiency and power output of the Hercules engine. The curves with the letter "W" following the fuel identification numbers show the results of water injection. The tests with water injection in the Hercules engine might be summed up as follows: For low octane fuels of high distillation range, the maximum safe sustained load could not be increased because sufficient water to limit detonation could not be injected without dropping the load. However, for a low octane fuel with a low distillation range, the maximum safe load was increased 42.5 per cent, and as much as 28 per cent without appreciable sacrifice of thermal efficiency.

Medium octane fuels (23 to 30) responded fairly well to water injection, showing a useful power increase of 24.6 per cent and 10 per cent, respectively. High octane fuels (34.5 to 43) exhibited negligible power increases and then only at great loss in thermal efficiency.

It can be seen that the thermal efficiency curves for a fuel when using water crosses the efficiency curve for the fuel without water injection at, or very close to, the point of maximum safe sustained load (or medium detonation). This is especially noticeable with D-21, D-26, D-27, D-28, and D-30. Therefore, it may be said that, in general, the use of water increases the thermal efficiency of a distillate only when operating at such a load that detonation (without water injection) would have had an intensity greater than "medium." Conversely, thermal efficiency is higher without water injection for loads which do not cause more than medium detonation. No more water should be injected than that required to reduce the detonation to medium intensity.

Water injection was of little practical value with the McCormick-Deering engine, as thermal efficiency was always seriously reduced.

A consideration of the foregoing experiments and tests, and review of the literature, has led the authors to prepare the following minimum specifications for a generally satisfactory distillate fuel intended for use in the conventional low-compression tractor of today:

Gravity not below	38.0 deg API
Initial point not above	360 deg F
10 per cent point not above	390 deg F
30 per cent point not above	420 deg F
50 per cent point not above	435 deg F
70 per cent point not above	450 deg F
90 per cent point not above	480 deg F
95 per cent point not above	515 deg F
End point not above	540 deg F
Octane rating not less than	30.
Sulphur content not over	0.20 per cent.

Color: Fuels meeting the above requirements should be dyed a suitable color to make identification possible. The sale of distillates dyed this color and not meeting the specifications should be prohibited by law.

[3]Wilson, R. E. and Barnard, D. F., Chemical hay for mechanical horses. S.A.E. Journal (Transactions), 35:359-369, Oct. 1934

Remodeling Possibilities for Farm Homes

By H. E. Wichers

THERE IS no question but that remodeling and repairing will constitute the major portion of farm house construction for the next few years. Of course, there will be new houses, but a large majority of our farms already have farm houses, and it is reasonable to expect that an attempt will be made to keep these houses in condition, rather than build new.

As to the character of these farm houses, what are they and what will they tend to become? I think we can answer that very simply, and yet indefinitely, by saying that the character of these houses will depend upon the conclusions that farm people reach in regard to the position of the farm house in their concept of things. Whether we know it or not, or whether we exercise this power or not, we hold the reins which, at least in a measure, direct public thinking about farm houses. If we think carefully and arrive at sound conclusions based on fact and reason, these conclusions will have a definite and far-reaching influence on the conclusions reached by those who must either build new or remodel. If we continue to treat the farm house as something secondary, or something important but not as important as the chicken house or the barn, we can expect that attitude to have a measure of influence. On the other hand, if we realize that the farm and its activity exist for the individual who runs that farm, then we will consider this individual a little more and the thing that he produces a little less. The result will be beneficial because we have placed important things first. So the nature of our thinking governs the nature of our conclusions, and our conclusions or convictions will in a measure determine the nature of future farm houses.

You and I know that those who are interested in new houses or in remodeling old houses, are interested in information. They want to know what is being done and how. They will study new house plans primarily to get ideas and suggestions. Where does the lady go who wishes to remodel an old dress? Does she look through information on how to remodel old dresses, or does she look at a new dress catalogue and new dresses in the shops? There is no question about the answer. She wants the latest ideas, and she will get them from magazines, catalogues, and style shops. Then she will try to make her old dress as nearly like the new dresses as humanly possible. The same thing applies in house design. Much of the material that we present in the form of new house designs is being constantly used. They are studying and will continue to study these new ideas. Of course, material on how to remodel is important. But we must not neglect presenting the best that we know in a dramatic way. Certainly the fundamentals of new farm house design are just as applicable in remodeling as they are in the new house. The idea of the central rear hall, the proper location of the front door, and the work room are sound fundamental ideas and can be incorporated in remodeling work.

Many inquiries that reach me deal with old farm houses that it is desired to remodel. From the information and photographs presented in these inquiries, a large portion of these houses are of questionable value. It is often an open question whether it would be worth remodeling, or whether it would be better to tear the house down and build new. It is impossible to judge accurately from the material which arrives in the mail, so I make it a practice to warn these people to be sure of structural value before investing a large sum of money. In general, of course, a house older than twenty-five years is questionable. You will understand that some houses much older are sound, but if foundations, sill members, or studs are bad, it will be better not to send good money after bad.

In one case, the farmer wished to remodel. We wished to test out the advisability of remodeling. We visited the house and decided after an examination that the house was not worth remodeling; that in all likelihood it would cost more to remodel this old house than to build new. In this case, the farmer had "got along" for years and years. In place of building a convenient home, they had bought more land.

It is strange, but sometimes telling an individual that he should not and cannot do so and so, brings him to a quick decision that he will. In this case, it worked just that way. The farmer in question flared up at our decision that the house wasn't worth remodeling and decided that he was going to remodel, and he did. He remodeled this old house from plans that we supplied. He came out with a house that was many times more convenient and comfortable than the old house. He even went to the extent of installing air conditioning. Our verdict that the house was not worth remodeling still held because the latest reports we have show that the house was considerably more expensive than a new house containing the same cubic content would have been. It did help this particular farmer to tell him that his house wasn't worth the bother. One farm wife has a good home as a result of it.

Several experiences in remodeling farm houses have convinced me that people usually get what they really want. There may be shortage of money, but if there is a strong desire for an automobile or a corn sheller or a new kitchen, somehow those things will materialize. It is our business, then, to realize that fact and keep presenting sound information in the most forceful and dramatic way we know how.

Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Illinois, November 30, 1937.

Author: Rural architect, associate professor of architecture, Kansas State College. Mem. ASAE.

Dynamiting Ditches and Channels

WHERE the desired size of channel can be obtained with a single line of holes, the maximum can be expected from the dynamite, and, in general, the rule of thumb—one pound per cubic yard—can be adhered to.

It is agreed that where a ditch or channel can be made with a single line of holes, the blasting condition is ideal. Such loading may start with a half pound of ditching dynamite per hole, and go to as much as 150 pounds per hole. The general practice is to column load half-pound sticks up to five or six sticks per hole. Loads larger than that are usually bundle or large-cartridge loads, exploded in holes six to eight inches in diameter, which are made by means of a post hole digger.—*L. F. Livingston* in the du Pont Agricultural News Letter.

The Dynamic Properties of Soil

VII. A Study of the Nature of Physical Forces Governing the Adhesion Between Soil and Metal Surfaces

By F. A. Kummer and M. L. Nichols

TILLAGE is the greatest power-consuming operation on the farm, and therefore deserves much consideration from the standpoint of farming economy. Because of the importance of this operation, research in soil dynamics is conducted at the Alabama Agricultural Experiment Station to provide a more exact basis for the design of tillage implements, and to study the various types of equipment and tillage operations from the standpoint of more efficient utilization. In attacking this problem it is necessary that the contributing properties of soils and their reactions to tillage implements be determined, and that the materials used in the manufacture of those implements be studied in order to establish their true relationship to the problem.

It has been found that friction between the soil and the metal surface has a great influence upon the life and draft of tillage tools, because the intensity of this friction governs largely the wearing and scouring properties of the implement. The general laws of friction between soils and metals have been described by Nichols[1, 2]. He divided friction into phases, namely, A (compression phase), B (friction phase), C (adhesion phase), and D (lubrication phase). The graphical representation of the moisture-friction curve illustrated clearly that the C phase includes the maximum value of the frictional coefficient which assumes its sudden increase from the adhesion between metal and soil (Fig. 1). Since high friction constitutes a waste in power and possibly causes excessive wear of the tillage implement, it is logical that the principles underlying the phenomenon of adhesion should be investigated. This report deals with a method of measuring the adhesion between soil and metal surfaces. However, the work is of such scope and presents such a variety of possibilities to be studied that it is far from being completed. For this reason it is the purpose of this report to present the progress of the investigation to date.

Presented before the Power and Machinery Division at the fall meeting of the American Society of Agricultural Engineers at Chicago, December 1, 1937. This is the seventh paper of a series setting forth the results of soil physical studies conducted at the Alabama Experiment Station. Parts I to VI appeared in previous issues of AGRICULTURAL ENGINEERING. Released for first publication in AGRICULTURAL ENGINEERING with the permission of the Director of the Alabama Agricultural Experiment Station.

Authors: Respectively, assistant agricultural engineer, Alabama Agricultural Experiment Station (Assoc. Mem. ASAE), and assistant chief of research, Soil Conservation Service, U. S. Department of Agriculture; formerly head of agricultural engineering department, Alabama Agricultural Experiment Station (Mem. ASAE).

[1]Nichols, M. L. The Dynamic Properties of Soil. AGRICULTURAL ENGINEERING, vol. XII, no 4, pp. 259-264, 1931.

[2]Nichols, M. L. Soil and Metal Friction. AGRICULTURAL ENGINEERING, vol. XII, no 8, pp. 321-324, 1931.

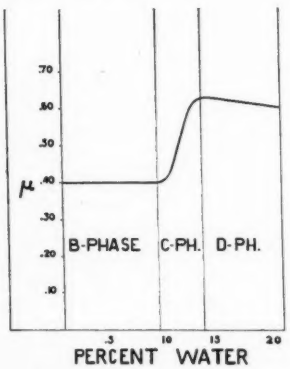


FIG. 1 CURVE SHOWING RELATIONSHIP BETWEEN SOIL MOISTURE CONTENT AND COEFFICIENT OF FRICTION FOR DIFFERENT FRICTION PHASES. A, COMPRESSION PHASE (NOT SHOWN); B, FRICTION PHASE; C, ADHESION PHASE, AND D, LUBRICATION PHASE

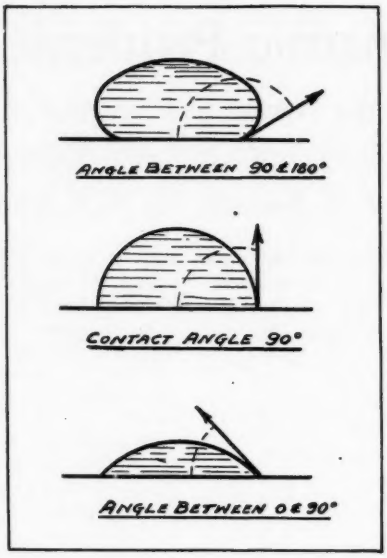
THEORY OF ADHESION

It is an accepted view that various solids are wetted to different degrees by a given liquid, also that one given solid may be wetted to different degrees by various liquids. It is further believed that the wetting power of each of the various liquids is specific in relation to a given solid. Unfortunately no specific data are available in the literature which will give the relative wettability of a solid by different liquids. A conception now quite generally appreciated is that "wetting power" is a function not only of the surface tension of a liquid, but also of the specific attraction operative between the solid and the liquid. The relative magnitude of this attraction or force of adhesion can deducibly be obtained in cases where the contact angle between the solid and the liquid is known.

Degree of Wetting. The contact angles between solids and liquids may be of different magnitudes varying from 0 to 180 deg (Fig. 2). Bartell and Osterhof[3] have shown that in those cases where a zero angle exists between solid and liquid, the solid will tend to become wetted spontaneously and completely by the liquid in contact with it. It follows from the principles of capillarity that the surface tension of the solid-air system must then be greater than the surface tension of the liquid and the interfacial tension of the combined solid-liquid system. At the other extreme it is likewise evident that no wetting of the solid by the liquid will occur if the contact angle is 180 deg.

When the contact angle of the solid-liquid system is equal to 90 deg, the force of adhesion may be said to be equal the force of cohesion of the liquid molecules. When the contact angle is between 90 and 180 deg, the force of adhesion is less than the force of cohesion, and a drop of liquid placed on a solid will pull itself together and recede from the solid until its characteristic contact angle is reached. When the solid-liquid contact angle is between 0 and 90 deg, the force of adhesion is greater than the force of cohesion, and such a liquid when placed on the solid will tend to spread upon its surface. In all such cases the extent of spreading will be limited by the surface tension of the liquid and by the contact angle which is characteristic of this system.

[3]Bartell, F. E. and Osterhof, W. J. The Measurement of Adhesion Tension Solid Against Liquid. Colloid Symposium Monograph, vol. V, pp. 113-134. The Chemical Catalog Comp., Inc., New York, N. Y., 1928.



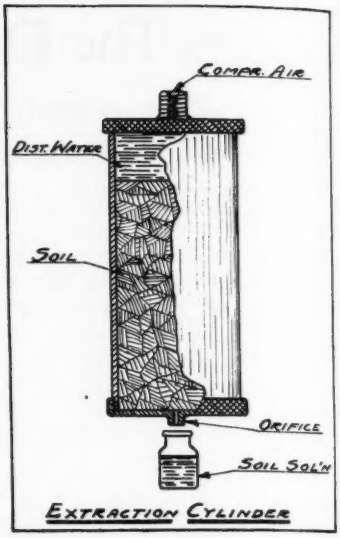


FIG. 2 (RIGHT) COMPARISON OF THE MAGNITUDES OF CONTACT ANGLES BETWEEN SOLIDS AND LIQUIDS VARYING FROM 0 TO 180 DEG. FIG. 3 (EXTREME RIGHT) SECTION OF SOIL EXTRACTION CYLINDER SHOWING THE METHOD USED IN OBTAINING SOIL SOLUTIONS

Soil-Metal Adhesion. The abovementioned and generally accepted concepts of adhesion give reasonable justification for applying these same principles to the adhesion taking place between the soil and the metal surfaces of the tillage tool. In this case adhesion consists of the molecular attraction between the molecules of the soil water (liquid) and the molecules of the metal surfaces (solid) which are in contact with the soil. In more exact terms, the adhesive attraction is between the electrostatic valences of the molecules on the surface of the metal, the electrostatic charges of the water molecules, and those on the colloidal surfaces of the soil particles in contact with the metal. The attraction of a metal for a liquid, the "wetting power," may be determined in the same manner as with any other solid, namely, by the angle of contact formed by a liquid when placed on the metal surface, or by the extent to which the liquid spreads over or wets the surface. The angle of contact depends upon the composition of the metal and the surface tension of the liquid. The surface tension of the liquid will be affected by the dissolved salts in solution, the temperature, and the hydrogen-ion concentration of the liquid.

Since metals used in the manufacture of tillage implements vary widely in chemical composition, the metallic substances are not homogeneous in their structure. Steel in general an alloy of iron and carbon, usually contains a number of additional ingredients in the form of alloying agents and impurities. It is evident from their physical and chemical properties that the impurities produce different reactions with the soil solution than the metallic ingredients. Test results have shown that during the adhesion process, when the soil solution is in contact with the solid, a localized corrosive action takes place. The intensity of this action depends largely upon the chemical composition of the metal and the nature of the ions in solution.

Localized Action. Speller[4] states in his theories of corrosion that the corrosion of iron is rarely uniform over the entire surface. Dissimilar metals in contact with each other, or with electrically conductive materials in solution, tend to accelerate corrosion locally. This action is caused by an electric current flowing through the solution from the more corrodible to the less corrodible material, an electric couple reaction.

Variations in concentration or composition of solutions in contact with a metal tend to localize corrosion at certain areas of the surface (accelerate it), and retard the action at others. This phenomenon is explained as actions taking place between the anodic and cathodic areas which exist upon the metal surface, due to the differences in composition, or as oxygen couples. These create differences in potential between various parts of the exposed surface. In the absence of other contributing factors the action would soon stop, because the polarizing effect of the hydrogen film formed on the cathodic area is a result of electrochemical reaction. The continuance of corrosion depends upon the removal of this film.

Electrochemical Theory. The electrochemical theory is now generally accepted as the one which best explains the preceding process. Iron like all other elements has a definite, inherent tendency to go into solution when placed in contact with water. When iron is immersed in water, hydrogen is the element plated out. This hydrogen gathers on the surface of the iron in the form of a molecular film. The presence of this film tends to obstruct or congest the progress of the reaction by insulating the metal from the solution. The reaction stops when the cathodic area becomes polarized with hydrogen and further corrosion depends upon the removal of the film of hydrogen causing the polarization. This can happen in two ways; either hydrogen combines with oxygen in solution to form water, or it escapes in a gaseous form. Dissolved oxygen is usually present in water solutions and removes the hydrogen by reacting with it to form water. The process is then free to continue at a rate determined by the speed with which oxygen removes the hydrogen. In acid solutions with a high concentration of hydrogen ions, the tendency for hydrogen to plate out is much greater and corrosion, therefore, is proportionately more rapid.

Factors Influencing the Rate of Corrosion. According to the foregoing discussion, the rate of corrosion would necessarily have to be dependent upon a number of factors which include:

1 The metal potential of the metallic iron
2 The hydrogen-ion concentration of the liquid

[4]Speller, F. N. Corrosion, Causes and Prevention. First Edition. McGraw-Hill Book Co., Inc., New York, N. Y., 1926.

3 The unequal distribution of the dissolved substance in solution on the metallic surface

4 The character and uniformity of the surface finish on the metal

5 The segregation of impurities in the metal

6 The composition of the metal

7 The ionic concentration or conductivity of the corroding solution.

It is evident, therefore, that any of these factors could markedly influence the adhesion process by their contribution to the corrodibility of the contact surface and its consequent surface change.

EXPERIMENTAL METHODS

Approach to Problem. A testing method was developed which took into consideration as many of the contributing factors as was technically possible.

Since adhesion in the case of soil and metal consists of the molecular attraction between the molecules of the soil water (soil solution) and the molecules of the metallic surface, it was decided to use the solution itself for the test. In order to establish the constants necessary for the evaluation of the contact angle, the surface tension of the solution and its density were determined. Further, to facilitate a possible correlation of the properties of the soil solutions with adhesion, the pH value and the conductivity of the solution were measured.

The variations in chemical composition and physical properties of commercial steels which cause differences in crystalline structure were taken into consideration. This was done by obtaining complete analyses of most metal specimens. The preparation of the metal samples was a highly time-consuming process, and therefore it was desirable to use the same samples under different heat-treatments. Consequently it was necessary to make permanent records of their structures. These records were obtained by the application of standard metallographic methods and the use of photomicrographs.

Soil Solutions, Extraction. A method of displacing the soil solution from the soil, as developed by Parker[5], was used to obtain the test liquid. The apparatus consisted of a number of metal cylinders which were partly filled with packed soil (Fig. 3). Distilled water was added to fill the remaining space above the soil. Then compressed air at a pressure of 100 lb per sq in was applied through the top of the cylinder causing the water, contained in the soil, to be ejected through a small orifice at the bottom. At the same time, the ejected soil water was displaced by the distilled water above the soil. Conductivity tests were made at frequent intervals in order to determine when the displacement of the soil solution was complete. The ejected soil water was kept in a refrigerator to prevent contamination by bacterial action.

Properties of Soil Solution. The surface tension of the solution was measured with a standard DuNuoy tensimeter[6]. The value of the surface tension served as a constant for the solution in the evaluation of the contact angle whose formula and mathematical interpretation will be shown later.

The conductivity of the solution was measured with a Wheatstone bridge arrangement[6] and its value recorded for possible correlation with the results and indications from the test.

The pH value of the solution was determined by the glass electrode method[7].

The surface tension, the conductivity, and pH value of the soil solutions used in the experiments are given in Table 1.

Metal Samples. A considerable number of metal samples including a great variety of standard plow steels, special alloy steels, and irons were used in this investigation. The metal samples were cut to a size of 1x2x1/2 in,

[5]Parker, F. W. Methods of Studying the Concentration and Composition of the Soil Solution. Soil Science, vol. XII, no. 3, September 1921.

[6]Mack, E., and France, W. G. Laboratory Manual of Elementary Physical Chemistry. Second Edition. D. Van Nostrand Comp., Inc., New York, N. Y., 1934.

[7]Naftel, J. A., Bradfield, R., and Schollenbarger, C. J. A Comparison of the Glass Electrode with Other Methods Commonly Used in Soil Reaction Measurements. Soil Research, 5: 222, 1933.

TABLE 1. CONDUCTIVITY, SURFACE TENSION, AND pH VALUES OF TEST SOLUTIONS USED

Soil solutions	pH value	Conductivity, * mhos	Surface tension, * dynes/cm
Buffer	4.06		
Distilled water		4.9×10^{-6}	
Cecil clay	4.00	1.44×10^{-4}	72.2
Greenville sandy loam	6.00	1.07×10^{-4}	73.2
Sumter clay	7.48	4.47×10^{-4}	72.7
Lufkin clay	6.80	2.64×10^{-4}	70.5

*Temperature, 20 C

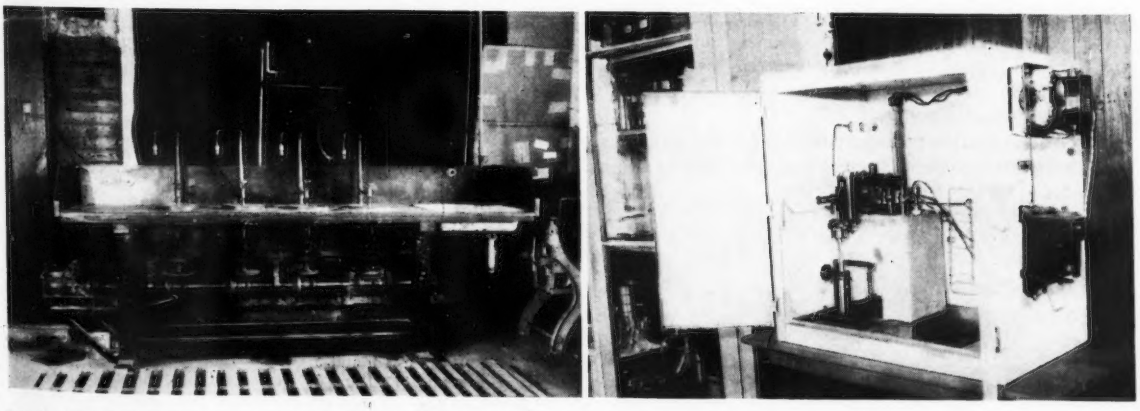


FIG. 4 (LEFT) POLISHING MACHINE USED IN PREPARATION OF METAL SAMPLES. FIG. 5 (RIGHT) CONSTANT TEMPERATURE COMPARTMENT AND MEASURING DEVICES USED IN THE DETERMINATION OF CONTACT ANGLES BETWEEN SOIL SOLUTIONS AND METAL SURFACES

and one side was prepared by grinding on a surface grinder. Then a uniform polishing treatment was given to that surface of all samples by the standard metallographic methods of disk polishing (Fig. 4). The abrasives used varied from emery paper No. 280 to broadcloth and levigated alumina for the final polish. Extreme care was taken to keep the samples absolutely clean for the adhesion test. The samples were etched after the test and examined under the microscope. A permanent record of each sample was made by taking photomicrographs of its structure.

Apparatus and Procedure. The equipment used in the determination of the liquid-solid contact angle consisted of an insulated compartment which housed the measuring devices. The inside temperature of the compartment was kept constant by a thermostatically controlled heating element. A water bath, the temperature of which was automatically controlled, served as a temperature regulator for the test solution. The solution was placed in a glass funnel in the compartment (Figs. 5 and 6). The lower end of the funnel connected to a leveling tube which provided an adjustment of the solution level. The funnel rested on the water bath with its lower end and the connecting tube submerged in the bath. Thus the solution was held at a constant temperature since both the bath and the air in the compartment were held at the same temperature level.

Two identical metal samples were fastened in a vernier slide with their polished faces parallel to each other. With this slide the samples could be adjusted to desired distances between faces with an accuracy of $\pm 1/200$ mm. The distances used in this experiment were one millimeter and two millimeters. The slide was then placed above the solution so that the samples were partly immersed in the liquid. The contact of the liquid with the metal surfaces caused the formation of a meniscus at the surface of the solution between the polished faces of the samples. To measure the height of the meniscus, a vertical vernier slide similar to the one mentioned above operated a telescope in front of the meniscus and thus provided accuracy in measurement from an accessible position. A neon light was placed behind the apparatus in such a manner that it was always directly behind the meniscus. A neon light source was used because it provided a column of light and generated less heat than an ordinary light bulb. Two readings were taken, one for 1 mm distance between parallel faces and one for 2 mm distance. From the difference between the two heights of the menisci for the two different widths the value of h for the formula was calculated from the differences of the measured heights (See formula). The values of W_1 and W_2, the widths between faces, remained constants by maintaining definite distances between the faces. These readings were repeated several times in order to establish a consistent average and to eliminate possible errors in reading.

From the obtained measurements and the constants of the solution, the angle of contact was calculated as follows:

$$h = \frac{2\,T\cos\alpha}{g\,\rho\,w}$$

where h = height of meniscus
T = surface tension of liquid
g = acceleration of gravity
ρ = density of liquid
w = width between parallel faces of metal samples
α = angle of contact

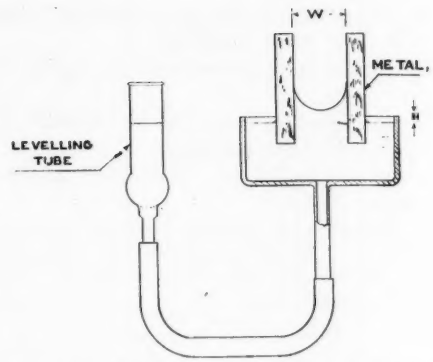


FIG. 6 SKETCH SHOWING THE PRINCIPLES INVOLVED IN THE MEASUREMENT OF THE CONTACT ANGLE

Solving for h from the differences in height for the two readings at 1 mm and 2 mm widths,

$$h_1 - h_2 = x$$

$$h = h_2 + x$$

$$h_1 = \frac{2\,T\cos\alpha}{g\,\rho\,w_1} \text{ and } h_2 = \frac{2\,T\cos\alpha}{g\,\rho\,w_2}$$

$$\frac{2\,T\cos\alpha}{g\,\rho\,w_1} = \frac{2\,T\cos\alpha}{g\,\rho\,w_2} + x$$

Since T, g, ρ are constants,

$$\frac{2\,T}{g\,\rho} = K$$

$$\therefore \frac{K\cos\alpha}{w_1} = \frac{K\cos\alpha}{w_2} + x$$

$$\text{or } K\cos\alpha\,\frac{1}{w_1} - K\cos\alpha\,\frac{1}{w_2} = x$$

$$\text{or } K\cos\alpha\left(\frac{1}{w_1} - \frac{1}{w_2}\right) = x$$

$$\text{or } \cos\alpha = \frac{x}{K}\left(\frac{1}{w_1} - \frac{1}{w_2}\right)$$

Since w_1 and w_2 are held constant, $\dfrac{1}{w_1} - \dfrac{1}{w_2} = C$

$$\therefore \cos\alpha = \frac{x}{KC}$$

RESULTS

The limited number of test results does not warrant any definite recommendations, but the indications obtained from some phases of the work seem worthy of a brief discussion.

It was found that the differences in grain structure with their possible difference in potential between the various grains materially affected the spreading angle and the subsequent adhesion between the soil solutions and metal surfaces (Table 2).

The presence of alloying materials in steels and even in cast iron showed in some cases a considerable decrease in

TABLE 2. VALUES OF CONTACT ANGLE FOR DIFFERENT SOIL SOLUTIONS IN CONTACT WITH DIFFERENT PLOW STEELS AND CHEMICAL ANALYSES OF METALS

Name of metal samples*	Contact angle in deg for different soil solutions: Sumter	Cecil	Greenville	Lufkin	Chemical analysis of plow steels in per cent: C=	Mn	P	S	Si	Ni	Cr	Mo
IHC-Hd. and Dr.	74	78	77.6	75.6	SAE							
IHC-Hd.	76.5	78.5	79.8	78.0	1095							
John Deere	75.5	77.5	76.7	76.4								
No. 2 Plow	73	79	78.3	76.5								
IHC S.C.	76	79.5	80.2	77.2								
No. 3 Plow	75	77.4	78.2	78								
No. 1 Plow	74.5	75.5	77.6	75.6								
R A	74	76	76.3	74.8	0.48	0.78			0.28			0.29
R B	74.5	78.5	77.6	75.8	0.635	0.83	0.017	0.013	0.24			0.24
R C	75.6	77.5	76.8	75.8	0.635	0.83	0.017	0.013	0.24			0.24
R D	74	76.9	76.3	75.9	0.48	0.78	0.016	0.019	0.28			0.29
Ill. St. 3-018	73.8	76	78.4	74.8	0.65	0.75	0.011	0.006	0.23			0.24
Ill. St. 3-0569	73	76.4	78	75.6	0.43	0.75	0.010	0.007	0.18			0.80

*Legend

TABLE 3. VALUES OF CONTACT ANGLE FOR DIFFERENT SOIL SOLUTIONS IN CONTACT WITH DIFFERENT ALLOY STEELS AND CHEMICAL ANALYSES OF METALS

Name of metal samples*	Contact angle in deg for different soil solutions: Sumter	Cecil	Greenville	Lufkin	Chemical analysis of alloy steels in per cent: C=	Mn	P	S	Si	Ni	Cr	Mo
INC A	78.5	78.2	79.7	77.8	0.16	0.44				1.44		
INC B	78.1	80.7	78.8	79.3	0.75	0.32			0.19	3.08		
INC C	78.4	77.8	78.1	78.2	0.15	0.45				3.43		
INC D	78	78.7	79.2	78.9	0.15	0.58			0.24	4.72		
INC E	80.2	80.5	81.3	79.7	0.17	0.47				1.26	0.62	
INC F	80.4	80.4	78.4	80.5	0.50	0.53				1.75	1.06	
INC G	79	79.2	79.6	78.9	0.14	0.56			0.23	1.80		0.26
INC H	83	80.6	80.2	82.5						8	18	
INC I	83	81.4	80	82.2	0.35	0.25			0.50	20	35	
INC K	79.5	80.6	80.8	80.1		Monel						
INC L	80.8	82.4	82.2	82.1						88	12	
INC M	81.5	80.7	81.8	80.9	0.09					11.12	20.61	

*Legend

TABLE 4. VALUES OF CONTACT ANGLE FOR DIFFERENT SOIL SOLUTIONS IN CONTACT WITH DIFFERENT CAST IRONS AND CHEMICAL ANALYSES OF METALS

Name of metal samples*	Contact angle in deg for different soil solutions: Sumter	Cecil	Greenville	Lufkin	Chemical analysis of plow steels in per cent: C=	Mn	P	S	Si	Ni	Cr	Mo
Anchor cast	65.5	76.7	73.7	66.5								
Arrow brand	68.9	72.7	72	69.8								
Alloy plow	76.5	79	79.8	78								
INC 3319	51	69.3	70.4	62.8	2.77	0.49			2.16	1.15		
INC 3291	55	73.8	75.2	65.7	2.50	0.43			2.11	2.09		
						Medium						
INC 3284	64	74.3	74.8	68.4	3.13	.79			1.02	3.89		Cu
INC 2718	80.2	82.5	79.8	80.5	3.0	1.0			1.50	15.39	2.27	6.0

TABLE 5. EFFECT OF HEAT TREATMENT OF STEELS ON CONTACT ANGLE

C- 9-10	77.6	77.5	79.8	79.5	1.2 C S.C.	W.Q. at 1650 deg F
C-11-12	74.5	75.8	75.8	77.0		Oil Q. at 1650 deg F
C-15-16	76	75.7	76.6	75.5		Oven cooled
B- 9-10	78.4	77.5	76.8	78		SAE 1095 W. Q.
B-11-12	77.6	75.8	78.5	76.8		Oil Q.
B-13-14	77.5	77.3	73.7	72.3		Air cooled
B-15-16	72.8	72.6	74.0	74.6		Oven cooled

*Legend *Metal Samples*:

IHC—International Harvester Co.
John Deere—John Deere Implement Co.
Ill. St.—Illinois Steel Corp.
RA (etc)—Republic Steel Corp.
INC—International Nickel Co.

surface wetting (Table 3). The decreased adhesion force in the alloy steels was probably due to the fact that the corrosion-resisting properties inherent to some alloy steels affected the surface reactions taking place during the period of contact of the soil solution with the metal. Alloys, which tend to produce homogeneous structures in the austenitic state, are electrically less active and thus decrease the galvanic action on the surface which logically reduces the surface reactions. Since all corrosion prevention is accomplished through the action of protective films, the passivity associated with alloy steels is thought due to the presence of an oxide type of film kept constantly in repair by the action of the atmosphere. The films on stainless steel are thought to be very thin (one to two molecular layers). The thinner films give the best protection, as the presence of a thin film indicates that the protective film stifles its own growth. Thus the decreased wetting exhibited by the alloy metal samples may be due to a decrease in the thickness of the protective film.

Metals which had free graphitic carbon, such as cast iron, had a great attraction for the soil solutions (Table 4). This was thought to be due to the absorption of hydrogen by the graphite, thus preventing the polarization of the active surface. It is also possible that the presence of impurities may have been partly responsible for this increased attraction.

The test results also indicate that grain size and other structural differences due to heat-treatments affect adhesion or the wettability of the metal surface, which seems to decrease with increasing hardness of the metal (Table 5).

While the results given in this article exhibit definite trends in the behavior between metal surfaces and soil solutions, they are as yet inadequate for direct recommendations. It is hoped that they can be further investigated and carried to a more satisfactory conclusion, so that in the future, perhaps, test results of this type may serve as a guide in the selection of materials for implement construction.

SUMMARY

This paper is primarily intended to give a progress report of a study of the adhesive forces between soil solutions and metals. A general

discussion of the theories of adhesion and their application to soil-metal adhesion is given.

The factors contributing to soil-metal adhesion are listed and discussed in detail.

Discussions and illustrations of the apparatus used and the methods of procedure followed are included.

It was found that differences in grain structure materially affected the adhesion between soil solutions and metal samples.

Cast irons, containing free graphite carbon, have a great attraction for the soil solution.

The presence of alloying materials in steels and even in cast irons showed in some cases a considerable decrease in surface wetting.

Grain size distribution and other structural differences due to heat-treatments affected adhesion or the "wettability" of the metal surface.

What Agricultural Engineers Are Doing

FROM THE U. S. BUREAU OF AGRICULTURAL ENGINEERING

HARRY F. Blaney attended an all-day session at Las Vegas, Nev., called by State Extension Director Cecil Creel, on water and soil conservation problems in southern Nevada. The meeting was attended by representatives of the Department of Agriculture and state and local agencies. The conference dwelt primarily on projects in Lincoln and Clark Counties. It was brought out that draining alkali lands is one of the most important problems in connection with water and soil conservation in this area, and that better coordination of the work of the various federal, state, and local agencies is desirable.

* * *

Studies of orchards near San Dimas and Glendora, Calif., to determine the relation of use of water to yield of fruit, according to a report by Colin A. Taylor, indicate the dominant influence of soil type. High and sustained production, together with economical use of water was associated with the deeper loam soils of medium texture. The seasonal use of water was higher on the open gravelly loams and this seemed to be connected with more frequent irrigations and lower efficiency of application. Trees on the compact red soil were generally small and the production low, and many of these orchards had a low seasonal use of water.

* * *

The Oregon Agricultural Experiment Station plans to publish two bulletins covering the past six years' work at the Medford station on the irrigation of pears, material for which is being prepared by M. R. Lewis, assisted by R. A. Work and R. B. Allyn. One will deal with responses of pears to irrigation, including the effect of different moisture conditions in the root zone on the growth of trees and fruit, and on the quality of fruit; the other with the relation of pruning and thinning to growth of trees and yield of fruit. Dr. Aldrich of the Oregon station is co-author of these two bulletins. He plans to write a third bulletin for this series, on blossoming and set of fruit. Preliminary draft of the text for the first publication is almost completed.

* * *

Under the snow survey and irrigation water supply forecasting project, J. C. Marr made final preparations for receiving snow survey information from cooperators and for issuing the January 1 report. R. L. Parshall made a trip to the Blue Lakes area where he located a snow course at an elevation of 10,000 ft. He conferred with representatives of the Forest Service. Bureau of Reclamation, state engineer's office, and the Denver water board to make final arrangements for observations on all Colorado snow courses this coming season.

Carl Rohwer prepared maps showing location of the major drainage areas, snow courses and stream-gaging stations in Colorado, Wyoming, and New Mexico. R. A. Work constructed a model on a scale of 1-to-6 of one of the deep-snow shelter cabins, and prepared a paper on construction of snow survey shelter cabins for publication at a later date. R. B. Allyn installed short-wave radio transmitting and receiving equipment at the Medford station and at the Diamond Lake snow course, and weekly contact schedules are now in effect for regular reception of snow measurements from this isolated location. A similar installation is being set up to establish contact with the snow observer at Goolaway Gap. Winter sports information was assembled by all field men of the division engaged on this project, and broadcast each Friday, beginning December 17, from Salt Lake City, Denver, Boise, and San Francisco. A local broadcast for Oregon was sent out from Medford.

* * *

In connection with the project on storage of water underground, Dean C. Muckel supervised the construction of a one-foot Parshall flume on the Lower Cucamonga (Calif.) spreading area. Revised plans of the Anaheim spreading system were gone over with the chief engineer of the Orange County flood control district, and arrangements made to enlarge the measuring flume formerly used to measure the inflow to the spreading basins. This enlargement became necessary because of diversions built during the summer to supply flood water from the Placentia area to the spreading grounds. Stream flow records for Cucamonga Creek were obtained from the U. S. Geological Survey in order that by deducting the flow past the flumes from the flow which passed the USGS station, the amount of water percolating in the upper section of the spreading grounds could be determined.

* * *

Laboratory soil tests were made recently by Harry G. Nickle, mostly on samples from proposed dam sites in the Huntsville State Park in Walker County and from the Fort Phantom Hill Dam near Abilene, Texas. As a result of shrinkage tests made on small test cylinders of earthen materials, curves have been made showing the volumetric shrinkage during a period of thirty days. With the aid of these curves and the mechanical analysis of samples (indicated by percentages in each of the six main size groups), it is possible to estimate quite closely the volumetric shrinkage of any given material as soon as the mechanical analysis has been determined. A more exact figure can be obtained by shrinkage measurements for a period of five or six days, as it has been found that on the small cylinders used, almost no shrinkage will occur after that length of time. The Texas Board of Water Engineers is frequently requested to furnish the total volumetric shrinkage of a given material.

* * *

E. M. Mervine and S. H. McBirney attended the meeting of the American Society of Sugar Beet Technologists in Salt Lake City, Utah, on January 11, 12, and 13. This new organization is the outgrowth of several round table meetings held at Fort Collins, Colo., during the past four years for discussion of sugar beet research problems. Bureau engineers have taken part in these meetings and in the development of the Society.

FROM THE U. S. FOREST PRODUCTS LABORATORY

THE FOREST Products Laboratory has recently erected a one-story plywood house in which are embodied the latest developments of prefabricated plywood stress-covered panels. Featured in the panel construction is the use of water-resistant phenolic-resin bonded plywood for exteriors and exposed parts, the incorporation of moisture barriers in the walls, the use of insulation for increased fire resistance and for heat insulating purposes, and the use of natural-finished wood panels for some of the walls and floors. The building has been erected on the Laboratory grounds, and will be used for experimental purposes and to determine the *(Continued on page 84)*

Contributions Invited

All public service agencies (federal and state) dealing with agricultural engineering research and extension, are invited to contribute information on new development in the field for publication under the above heading. It is desired that this feature shall give, from month to month, a concise yet complete picture of what agricultural engineers in the various public institutions are doing to advance this branch of applied science.—EDITOR.

"Fur," *said the Deacon,* "'t's mighty plain thut the weakes' place mus' stan' the strain . . ."

THE ONE-HOSS SHAY

Now in building of chaises, I tell you what,
There is always *somewhere* a weakest spot,—
In hub, tire, felloe, in spring or thill,
In panel, or crossbar, or floor, or sill,
In screw, bolt, thoroughbrace,—lurking still,
Find it somewhere you must and will.

But the Deacon swore (as Deacons do, with an "I dew vum" or an "I tell yeou,")
He would build one shay to beat the taown
It should be so built that it *couldn't* break daown:
—"Fur," said the Deacon, "'t's mighty plain
Thut the weakes' place mus' stan' the strain;
'n' the way t' fix it, uz I maintain,
Is only jest
T' make that place uz strong uz the rest."

HE was born 200 years too soon—that delightful deacon who built the famous one-hoss shay — for he was an engineer at heart. With his penchant for making each part "uz strong uz the rest" he was doing just the job that designing engineers are accomplishing today with such outstanding success.

And the parallel does not stop there.

When the deacon "inquired of the village folk" he was going to headquarters for help and cooperation in finding better and stronger materials, just as designing engineers are when they call in alloy specialists from the metallurgical laboratories of Carnegie-Illinois.

When he selected "crossbars of ash from the straightest trees" and "steel of the finest, bright and blue" he was exercising the same painstaking selection of materials as designing engineers when they specify newly developed grades of U·S·S Carilloy Alloy Steels to strengthen vital parts.

We salute these ingenious engineers — the modern counterparts of Holmes' ingenious Deacon.

We take pride in supplying them with the finest alloy steels it is now possible to make, for strengthening the vital parts in their designs. We take pleasure in working with them, developing together even finer alloy steels to achieve new heights in smooth performance.

Taken from "The One-Hoss Shay" by Oliver Wendell Holmes—because it so aptly illustrates the reason for the increasing use of U·S·S Carilloy Alloy Steels.

U·S·S CARILLOY ALLOY STEELS

CARNEGIE-ILLINOIS STEEL CORPORATION

Pittsburgh *Chicago*

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*

United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

THIS SPRING...

BE THE EARLY BIRD

- **ORDER HIGH COMPRESSION TRACTORS FROM THE START**
- **SELL WITH THE FASTEST GROWING TRACTOR TREND TODAY**
- **MAKE 1938 YOUR RECORD YEAR**

MANY TRACTOR DEALERS set all-time records in 1937.

EVERY TRACTOR DEALER CAN SET A NEW ALL-TIME RECORD IN 1938!

Start right now to sell *with* the fastest growing trend in tractors today—high compression.

Many farmers were disappointed last year because they and their dealers had to wait to get high compression tractors. That's no wonder when you look at the way the idea of high compression has grown.

The first standard high compression tractor was announced to the trade late in 1935. Now —only *twenty-eight months later*—nine manufacturers make high compression tractors and two more offer high compression equipment optionally. In the last few months of 1937, three new high compression tractors were announced. More are on the way for 1938.

So, the first step to a record 1938 is to specify and demand high compression tractors on your Spring orders *right now*. Then they will come through from the factory equipped with high compression motors at no extra cost. Get all the booklets, manuals and information your manufacturer has on this development. Then talk, demonstrate, and sell high compression right through 1938.

HOW TO MOVE USED TRACTORS

Some customers can't buy a new tractor just now. However, many will be in the market for a good used tractor. Sell them a better used tractor by changing it over to high compression. You can move your stock of used tractors a lot faster if you high compression them and demonstrate the extra power resulting from high compression. Practically all tractor companies supply high compression ("altitude") pistons or cylinder heads to convert older models to high compression.

For a record 1938, ride the trend to high compression! Ethyl Gasoline Corporation, Chrysler Building, New York, N. Y., manufacturers of anti-knock fluids used by oil companies to improve gasoline.

NEWS

Where the West Began and Where Many Ag Engineers Will Be June 27 to 30, 1938.

MORE THAN 335 years ago, December 16, 1602, eighteen years before the Pilgrims landed on America's east coast, an intrepid Spanish explorer, Sebastian Viscaino, dropped anchor in a "noble harbor" on the west coast.

Viscaino had been ordered by his viceroy, Count of Monterey, Mexico, to find a refuge from pirates for the Spanish galleons engaging in trade with Pacific islands and the Orient. Cargoes of spices, silks, and other treasures were being brought to the Mexico west coast, transported overland to Vera Cruz, and reloaded on boats for shipment to Spain.

In honor of his Viceroy, Viscaino named the shelter he had discovered Monterey (mountain king). In his report he referred to the "infinite number of very large pines" and the "oaks of prodigious size". He was much impressed with the climate—balmy days in December. (This is the earliest recorded example of characteristic California publicity.)

In reality, Viscaino was not the first Spaniard to visit the region; Juan Rodriquez Cabrillo had preceded him into the bay as early as 1542, and named his discovery "The Bay of Pines." For some reason—perhaps the pirates became less active—the Spaniards did not bother to return to their newly acquired land for another century and a half. In 1770, an overland expedition from Mexico City established the Presidio and the Mission.

From this date the Monterey Peninsula was continuously occupied. It was the seat of Spanish government in California (while Philadelphia was the capitol of the Colonies) and continued under Spanish rule until 1821, when Mexico seceded from Spain. The interesting development of the territory continued, albeit through a period of political uncertainty until 1846, when after two abortive attempts the area was finally claimed for the United States. Monterey was the first capitol of the state, adding another to the list of "firsts" which total to an "historical heritage that makes it stand out like a nick in Time itself."

History, personality, and old buildings are not the only appeal of the Monterey Peninsula, however. The climate is peppy, with chill and light fogs perhaps more common in the summer than at other seasons. From the days of the early Spanish hacienda (ranch home) the residents have been noted for their attractive mode of living. Today the area is one of the most favored resort areas of the state.

Sport enthusiasts find excellent facilities for golf, tennis, fishing, hiking, swimming, riding, shooting, archery, and a host of more sedentary activities. Camera fiends track down the best shots of the old adobe buildings (many in use when Washington served as President), the surf breaking on the rocks, the lighthouse, or the fishing fleet riding at anchor in the bay. Nature lovers enjoy the beauties of the famed 17-Mile Drive, the recently opened highway along the coast, and the reverence-inspiring groves of California redwoods. Those of artistic inclination enjoy Carmel, internationally renowned village of 3,000 population which boasts more names in "Who's Who in America" than most cities.

To care for its visitors the Monterey Peninsula has hotels and resorts of all descriptions, from one of the nation's outstanding resort hotel properties to modest automobile courts. One of the most attractive and comfortable convention sites to be found in the state is Asilomar (resort by the sea). Originally established and operated by the national YWCA as a convention site for young peoples' groups, it has recently been taken under private management and operated as a year-around resort. It is here that the American Society of Agricultural Engineers will assemble its membership for the Society's annual meeting June 27 to 30, 1938.

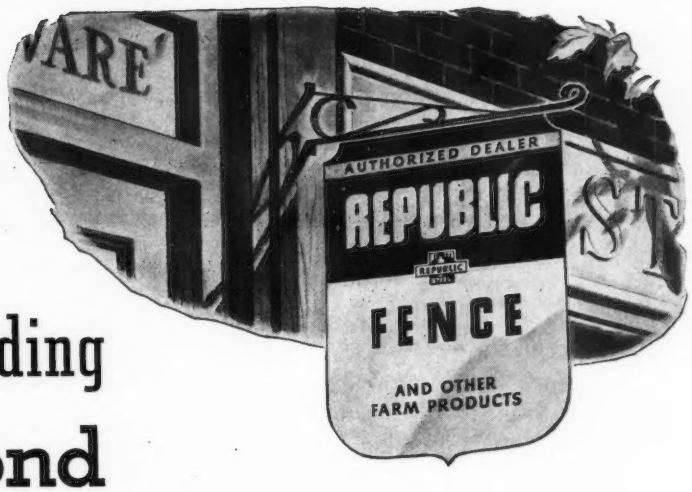
ASAE Meetings Calendar

June 27 to 30—Annual meeting of the Society, Asilomar at Pacific Grove, Calif.

New Officers of Pacific Coast Section

AT A MEETING of the Pacific Coast Section of the American Society of Agricultural Engineers held at Davis, California, January 8, the following officers were elected for the ensuing year: *Chairman,* H. B. Walker, professor of agricultural engineering (head of department), University of California; *first vice-chairman,* R. E. Storie, associate soil technologist, University of California; *second vice-chairman,* L. N. Brown, agent (irrigation assistant), Bureau of Agricultural Engineering, U. S. Department of Agriculture; *third vice-chairman,* L. J. Smith, professor of agricultural engineering (head of department), State College of Washington, and secretary of the Washington Committee on the Relation of Electricity to Agriculture; *secretary-treasurer,* W. W. Weir, drainage engineer, division of soil technology, University of California. A. E. Backman, engineer-appraiser, Federal Land Bank, Berkeley, was elected a member of the Executive Committee, and the retiring chairman of the Section, J. P. Fairbanks, agricultural engineering extension specialist, University of California, remains as ex-officio member of the Executive Committee.

AT THE LEFT IS SAN CARLOS MISSION AT CARMEL, CALIF., ERECTED IN 1797, AND AT THE RIGHT IS MIDWAY POINT ON THE SEVENTEEN MILE DRIVE ON THE MONTEREY PENINSULA IN CALIFORNIA



REPUBLIC Is Welding A Closer Bond

BETWEEN AGRICULTURE AND THE STEEL INDUSTRY

Pioneers in agricultural research and educational programs

REPUBLIC, last of the major steel producers to enter the agricultural field, already sets the pace in coordinating steel's activities to meet the needs of agriculture — the industry that feeds and clothes the nation.

Republic pioneered in the establishment of an Agricultural Extension Bureau, under the direction of a professional agricultural engineer, to promote the more efficient and profitable use of steel on the farm.

Republic, through its Fellowship at Iowa State College, Ames, Iowa, led in the practical application of science and research to the development of new and improved uses of steel in agriculture.

Republic's new all-sound motion picture — "Steel, Servant of the Soil" — is the first film to offer a complete course of instruction on approved methods of fence erection, combined with interesting sequences on the development and manufacture of farm fence.

Finally Republic leads with the publication of "The Fence Handbook" by Prof. Henry Giese of Iowa State College — perhaps the most complete and authoritative book ever written on this important subject.

Already a leader in the development and production of steels for the manufacture of farm implements and machinery, Republic sets out with the same aggressive, pioneering spirit to provide better and more economical steel products for the farm.

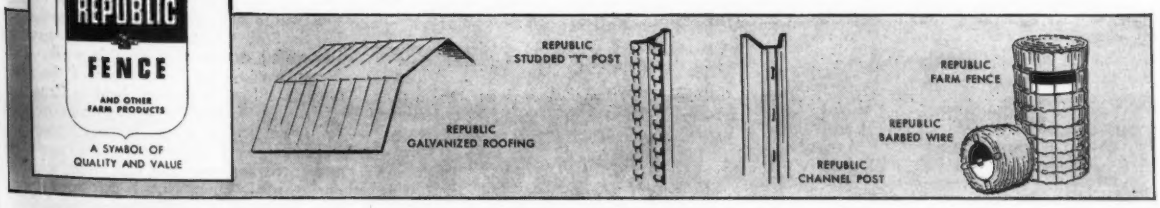
To this great purpose, Republic has dedicated all the knowledge of its highly trained metallurgical and engineering staffs and all the facilities of its finely equipped laboratories and modern plants.

Your comments and suggestions bearing on this subject will be gratefully received.

GULFSTEEL REPUBLIC STEEL

Republic Steel Corporation
Agricultural Extension Bureau
7850 South Chicago Ave. :: Chicago, Illinois
General Offices: Cleveland, Ohio

FARM PRODUCTS PLANTS at GADSDEN, ALABAMA, and CHICAGO



ASAE Joins National Fire Waste Council

THE American Society of Agricultural Engineers has recently been elected an organization member of the National Fire Waste Council of the U. S. Chamber of Commerce. Representatives of the Society will be appointed to cooperate in the work of the Council, so far as it relates to farm fire prevention and protection.

REA Specifications for Wiring and Plumbing

SPECIFICATIONS for farm wiring and plumbing approved by the Rural Electrification Administration for contract installations under its group bidding plan, have been issued in the form of mimeographed instructions to bidders. Copies may be obtained by agricultural engineers and other interested persons by writing to the REA at Washington, D. C.

Chemurgic Research Endowment Established

MICHIGAN State College has announced the establishment of a $500,000 trust endowment by the Rackham Foundation, for agricultural and chemurgic research at the College.

"Tentative plans call for utilization of the endowment in a study of the development of industrial uses for farm crops," Robert S. Shaw, president of Michigan State College, said in announcing the gift. "The College hopes to use some of the best trained men in both basic and applied science for finding entirely new and constructive uses for products of the farm. Such uses will provide the farmer with new markets and in turn bring about new work for labor and new activities in industry."

What Agricultural Engineers Are Doing

(Continued from page 78)

possibilities of this all-wood construction system as a means of providing low-cost housing.

* * *

Racking tests made at the Forest Products Laboratory on unplastered wall panels sheathed with fiberboard material have shown that, when well nailed, it forms an effective bracing to resist forces acting in the plane of the wall. While the fiberboard tested did not afford quite the rigidity of diagonal wood sheathing, the rigidity is several times that of horizontal sheathing.

The effectiveness of any sheathing as a bracing is dependent on the adequacy of the nailing, but it is particularly important with fiber insulating board that manufacturers' recommendations as to number of nails be followed to insure the fullest advantage of this material as a wall covering.

Personals

N. R. Bear, formerly assistant head, section of engineering, Soil Conservation Service, U. S. Department of Agriculture, is now assistant to the chief of the division of conservation operations of the Service.

K. B. Huff is author of Missouri Agricultural Extension Service Circular 374, entitled "Farm Lighting," and of mimeograph AEC-1, "How to Get Electricity on the Farm."

Harold E. Pinches presented a paper on "Economic Aspects of Rural Electrification" at the annual meeting of the American Farm Economic Association, Atlantic City, December 30, 1937.

L. L. Sammet is the author of Connecticut Agricultural Extension Bulletin 246 "Winterproofing Connecticut Houses." This bulletin distinguishes between the three commonly-used methods of conserving heat in houses, which are applicable to both old houses and new construction, with special emphasis on the work which can be done by the householder and with a discussion of relative costs and returns.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the January issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Elliott A. Adams, chief engineer, Massey-Harris Co., Inc., Racine, Wis.

B. Gwynne Burr, operator-manager, Upper Gwynne Farms, London, Ohio.

H. W. Dearing, Jr., assistant extension agricultural engineer, Alabama Polytechnic Institute, Auburn, Ala.

W. H. Farmer, assistant extension agricultural engineer, North Dakota Agricultural College, Fargo, N. Dak.

C. E. Gapen, chief, editorial and information division, Bureau of Agricultural Engineering, U. S. Department of Agriculture, 5312 South Building, Washington, D. C.

Louis M. Glymph, Jr., assistant agricultural engineer, section of sedimentation studies, Soil Conservation Service, U. S. Department of Agriculture, Columbian Building, Washington, D. C.

Leslie W. Johnson, draftsman, Deere & Mansur Works, Moline, Illinois. (Mail) 410 15th Ave.

Robert T. Jones, director of rural sales, Pennsylvania Power & Light Co., Allentown, Pa. (Mail) 2130 Tilgham St.

Joseph B. McGee, Jr., field supervisor, Agricultural Adjustment Administration, Chipley, Ga.

Whitley B. Moore, general manager, industrial division, The Timken Roller Bearing Company, Canton, Ohio.

C. J. Novak, junior agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 1945 Main Ave., Denton, Nebr.

W. J. Promersberger, assistant professor of agricultural engineering, North Dakota State College, Fargo, N. Dak. (Mail) 1017 7th St. N.

Patrick A. Robinson, assistant county agent, Charlotte C. H., Va.

William E. Urschel, designer and owner, Urschel Laboratories, 158 S. Napoleon St., Valparaiso, Ind.

TRANSFER OF GRADE

Walter H. Redit, assistant agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture, Washington, D. C. (Transfer from Junior Member to Member.)

Claude K. Shedd, agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) Agricultural Engineering Department, Iowa State College, Ames, Iowa. (Transfer from Member to Fellow.)

Student Branch News

GEORGIA

GEORGIA'S Student Branch of the ASAE held its first meeting of the winter quarter Monday evening, January 10.

The president, LeRoy Reaves, called the meeting to order. During the short business session W. C. Wheeler was elected secretary, replacing Fred Blitch who did not return to school this quarter.

A motion picture was presented under the direction of Fred P. Wohlford, representing the Libby-Owens-Ford Glass Company. The processes of making plate glass, safety glass, and structural vitrolite were shown. Samples of some of the products of the company were also exhibited. The subject was of particular interest, inasmuch as glass is constantly assuming a more important role in the building industry.

The program for the next meeting featured a motion picture showing the activities of the various student branches in the United States.—*H. S. Glenn, Scribe.*

OHIO

OHIO'S Student Branch of the ASAE held six regular meetings and participated in the "Engineer's Round-up" during the autumn quarter.

The first meeting was spent in organization of plans for the coming year. Our president presented the Branch with the FEI cup which we received at Urbana, Illinois last summer.

William Gill, president, and G. W. McCuen, chairman of the agricultural engineering department, gave introductory talks on the ASAE and agricultural engineering in general at our annual "Open House" meeting. A humorous skit "Whoopsie Daisy" depicted the scientific approach to an engineering problem. The remainder of the evening was spent in playing games and enjoying hot dogs and cider.

One of the leading implement companies presented a sound movie, "The Blacksmith's Gift," at our third meeting.

Members of the faculty gave detailed explanations of the various fields of agricultural engineering at our fourth meeting.

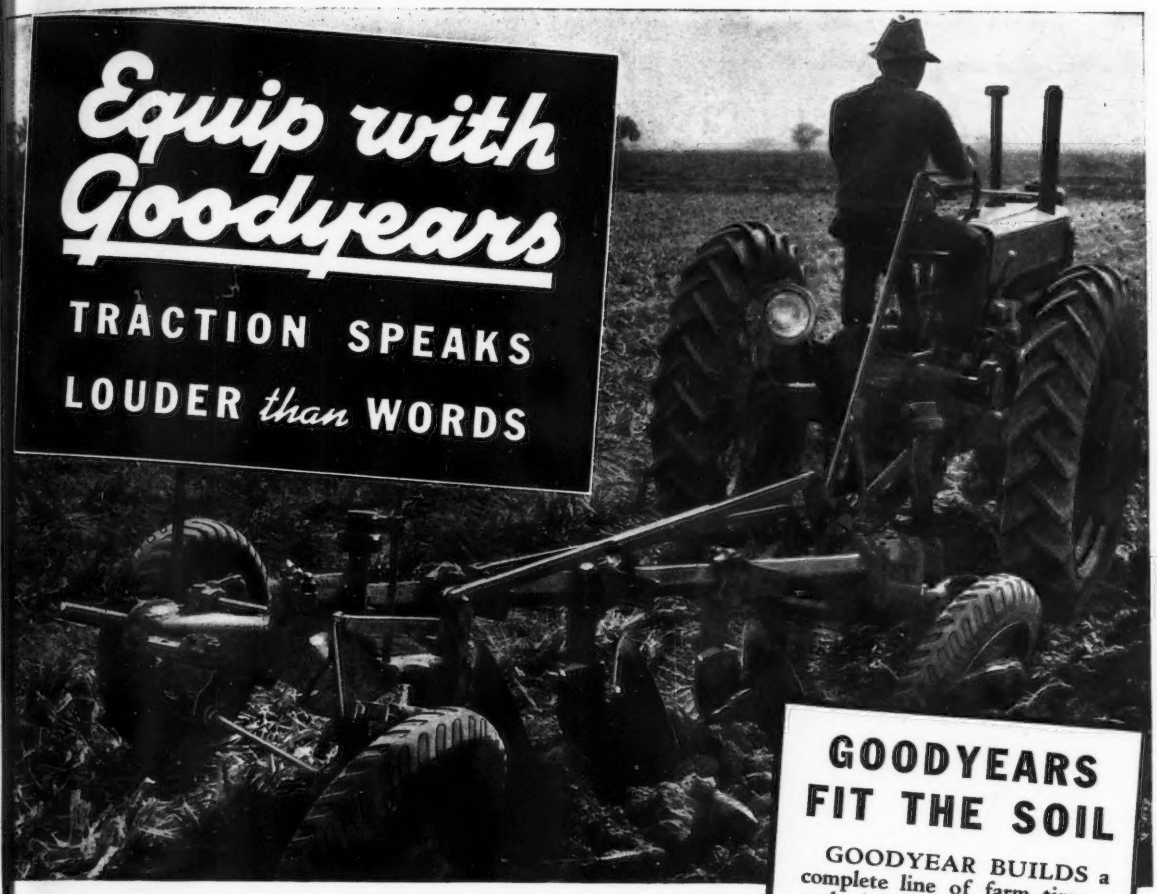
Ohio State was the first to show the branch activities movie at our meeting of November 23. Following this, reports of the ASAE annual meeting at Urbana, Illinois, last summer were given.

At our last meeting W. D. Ellison, hydraulic engineer in charge of the Coshocton water and hydrologic studies of the U. S. Soil Conservation Service gave an illustrated explanation of this work. J. B. Stere gave a brief description of the International Plowing Contest held in Canada.

Each of the above featured programs were followed by regular business meetings. Plans are well under way, and committees appointed for our next big event, which is our annual lunch stand during Farmer's Week, January 24-28 inclusive.—*Ralph Patterson, publications committee.*

Equip with Goodyears

TRACTION SPEAKS LOUDER *than* WORDS



TOP EFFICIENCY for your equipment. Maximum sales results from your dealers' efforts. You get both when the equipment you manufacture goes out on Goodyears.

No other make of tire will take you or your dealers so far—so fast—in going after farm tractor business.

Those tough, deep, earth-clenching lugs of the Goodyear Sure-Grip above tell you why. They speak for themselves—on the job or on the sales floor.

And the Sure-Grip's companion tires—the famous All-Traction, the Cane and Rice Field Special and others in the complete Goodyear line—will talk just as convincingly.

Each is built to fit a particular type of soil. For this reason the *right* Goodyear on the job will deliver more in tractor efficiency and drawbar pull than any other make of tire.

It's traction—not claims—that farmers want. It's performance such as Goodyear provides that will make your equipment show up better—make it sell easier—help you make the most of '38.

THE GOODYEAR TIRE & RUBBER COMPANY, INC., AKRON, OHIO

GOODYEARS FIT THE SOIL

GOODYEAR BUILDS a complete line of farm tires—each designed for a particular soil condition:

Sure-Grip—For maximum traction in heavy soils like mud, wet clay, gumbo.

All-Traction—For sand, loam—the "loose soils" found on the average farm.

Cane and Rice Field Special—For the extremes of soft going where utmost traction is imperative.

Ribbed Front Wheel Tractor Tire and Sure-Grip Implement Tire—For "free" wheels where traction is secondary in importance to easy-rolling.

GOODYEAR

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, principal agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

ELECTRIC BROODING, *J. C. Taylor* and *W. C. Krueger*. New Jersey Stas. Hints to Poultrymen, 24 (1936-37), No. 2, pp. 4, fig. 1. Certain practices which should be observed in the operation of an electric chick brooder are outlined.

INFLUENCE OF STORAGE TEMPERATURE AND HUMIDITY ON SEED VALUE OF POTATOES, *O. Smith*. [New York] Cornell Sta. Bul. 663 (1937), pp. 31, figs. 14. Field studies made, 1932-35, to determine effects of various methods of storing seed potatoes on subsequent plant growth and yield involved the Irish Cobbler and Smooth Rural varieties. Comparisons were made between storage in five commercial potato-storage houses and at various locations within each storage. Seed also was stored in constant-temperature cold-storage rooms during the entire storage period at both high and low humidities. Temperature shifts also were made for other treatments from 5 to 8 weeks before planting.

Low humidity in storage was found to result in the least sprouts per seed piece but in the longest individual sprouts. The most sprouts appeared on tubers stored at 40 F and later shifted to 50 F, but they were rather short. The final stand of plants usually was lower from seed stored at 32 F than from that stored at higher temperatures. Differences in the rate of emergence of plants were not so marked as expected from differences in average storage-season temperatures and humidities between the several commercial storages. This seemed due primarily to the fact that unless the tubers are removed from storage and planted early, the temperature in all storages for the last month or two exceeds sprouting temperature. Plants from tubers stored in constant-temperature cold-storage rooms appeared above ground in the order 50, 40, 35, and 32 F. The most stems per seed piece, the largest total number of tubers per plant, and the most U. S. No. 1 size tubers were produced by tubers stored at the higher temperatures. Storage treatments which produced plants above ground first did not always result in highest yields of tubers. Plants from tubers stored at any treatment with an initial temperature of 50 F matured about 7 to 10 days earlier than those stored at 40 F.

The two varieties responded differently in yields of tubers to the same storage conditions. The highest yields of Irish Cobbler usually were obtained from storage at 40 F for all or part of the storage period, whereas highest yields of Smooth Rural resulted from storage at 50 F for part or all of the storage period. Sprout growth with Irish Cobbler, it seemed, becomes too extensive for maximum yields when stored at 50 F, whereas with Smooth Rural sprout growth is slower and reaches optimum at 50 F or slightly lower.

In localities where early planting usually results in highest yields it would be desirable to store seed at the higher temperatures so that sprout growth at planting time would be as large as possible without having them damaged or broken off in the cutting and planting operations.

SOME EFFECTS OF LIGHT ON THE GROWTH, FLOWERING, ROOTING, AND BUDDING OF VARIOUS PLANTS [trans. title]. *P. Chouard*. Compt. Rend. Acad. Sci. [Paris], 202 (1936), No. 17, pp. 1454-1457. Experiments are briefly described on the effects of light intensity, duration, and quality on radish, spinach, bean, hybrid *Calceolaria*, peas, and *Brimeura* (ex *Hyacinthus*) *amethystina*. The advantages of supplementary illumination by an appropriate light, at optimum temperature, are stressed both in relation to precocity of flowering and to the processes of vegetative propagation.

THE STUDY OF THE EFFECT OF BLUE-VIOLET RAYS ON PHOTOSYNTHESIS, *R. H. Dastur and R. J. Mehta* (Ann. Bot. [London]. 49 (1935), No. 196, pp. 809-821. The rate of photosynthesis was studied in the light of an incandescent oil lamp, a 1,500-w gas-filled lamp, a "daylight" lamp, and a carbon arc lamp. The intensity of the blue-violet region in these four lamps increases in the order given, and the results of the study indicated that the photosynthetic rate also increases in the same order. Thus the importance of the blue-violet region of the visible spectrum is demonstrated.

The photosynthetic activity of sunlight was highest in white light, intermediate in red light, and very feeble in blue-violet light. Both the red and the blue-violet regions are deemed necessary to normal photosynthetic activity, and even with white light the assimilation depends not only on the total energy content but also on the distribution of radiations of different wavelength.

AN EXPERIMENT IN CHOPPING ALFALFA HAY AT THE TIME OF STORAGE, *T. E. Woodward and J. B. Shepherd*. Jour. Dairy Sci., 19 (1936), No. 11, pp. 697-706, figs. 2. The USDA Bureau of Dairy Industry has made a comparative study of finely chopped (¼-in), coarsely chopped (¾-in), and long alfalfa hays. These hays contained from 25 to 27 per cent moisture when stored.

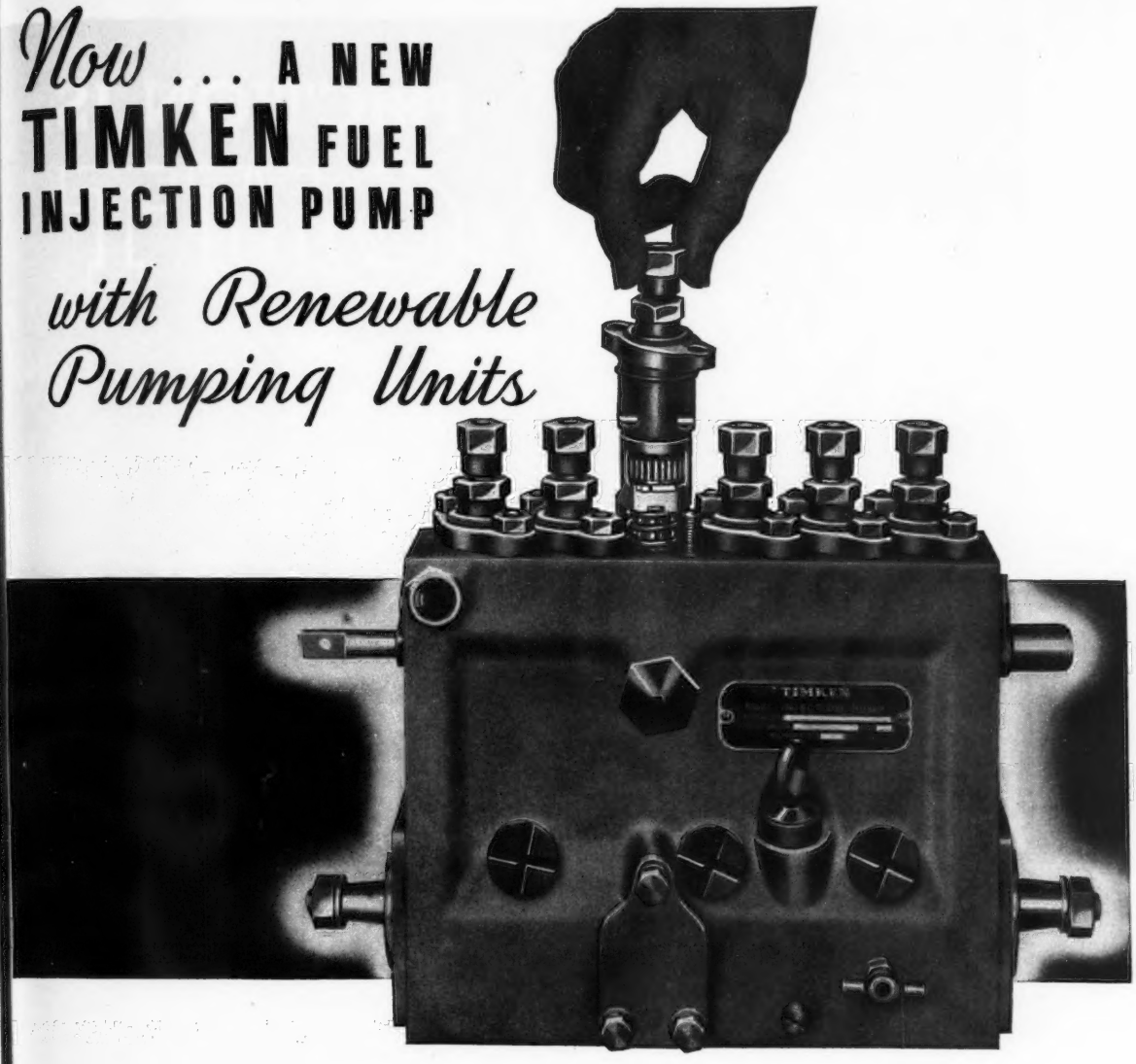
Approximately three times as much finely chopped and twice as much coarsely chopped hay could be put in a given space as hay in the long form. The finely chopped hay heated much more and the coarsely chopped hay somewhat more than the long hay. The chopped hays lost all trace of green color during storage, the fine hay ranging from black to brown and the coarse hay being light brown, whereas a considerable percentage of original green color was retained in the long hays. Carotene loss was extensive in all lots, but somewhat greater in the chopped hays. The loss of dry matter during storage, while moderate in all cases, was highest (6.5 per cent) in the finely chopped lot. The black chopped hay was the least palatable of the various lots, while the long hay proved somewhat more efficient than the chopped hays in tests with milking cows.

TESTS ON USE OF RUBBER TIRES AND STEEL WHEELS ON A FARM TRACTOR, *H. E. Murdock*. Montana Sta. Bul. 339 (1937), pp. 35, figs. 32. The results of a large number of tests of rubber tires and steel wheels on a standard wheel tractor are reported. All tests were run on summer-fallowed ground, part of which had been plowed and the remainder fallowed with a one-way disk, but all in approximately the same condition. The season was unusually dry, so the soil was very loose and dusty for most of the test period.

In fuel consumption the differences were small for the various series of tests with rubber tires, but decreased slightly with an increase of wheel weights. The fuel consumption with heavy loads decreased slightly when inflation pressure was decreased. The fuel consumption was less with rubber tires than with steel wheels by from one-sixth to two-fifths of a gallon per hour, or about 5 to 8 per cent less for the rubber tires. There was some variation with the load. An increase in the drawbar pull decreased the speed, this decrease being more rapid with the lower wheel weights. The maximum drawbar pull and horsepower were higher with the rubber tires. The maximum drawbar pull varies slightly with the inflation pressure; for the high inflation pressures the maximum drawbar pull is lower than for the lower pressures. The maximum practicable drawbar pull was about the same in all gears with rubber tires. The maximum horsepower with rubber tires was greater in the higher gears. The addition of wheel weights with the rubber tires increased both the maximum drawbar pull and the horsepower. The pull was increased an amount varying from one-third to two-thirds the value of the added weight and averaged nearly one-half the added weight. The increase in the maximum horsepower caused by adding 807 lb amounted to from 25 to 65 per cent.

The maximum drawbar pull with steel wheels was greater for the lower gears. The maximum horsepower was about the same for all gears with steel wheels. The maximum drawbar pull and horsepower with the large rubber tires were higher than for the steel wheels, while for the small tires they were less, but the differences were not great. The slip with rubber tires was generally higher than that with the steel wheels and lugs, except at the lower inflation pressures and with the higher amount of wheel weights. The slip with the rubber tires was greater with the higher inflation pressures. The slip was less with a larger wheel weight. The rate at which the slip increased with an increase in the drawbar pull was less with the large rubber tires than with the small tires. In high gear the tractor pulled larger loads when equipped with rubber tires than with steel wheels. Acre costs of operations with rubber tires were less in the high gears, while with steel wheels they were more uniform in the three gears. *(Continued on page 92)*

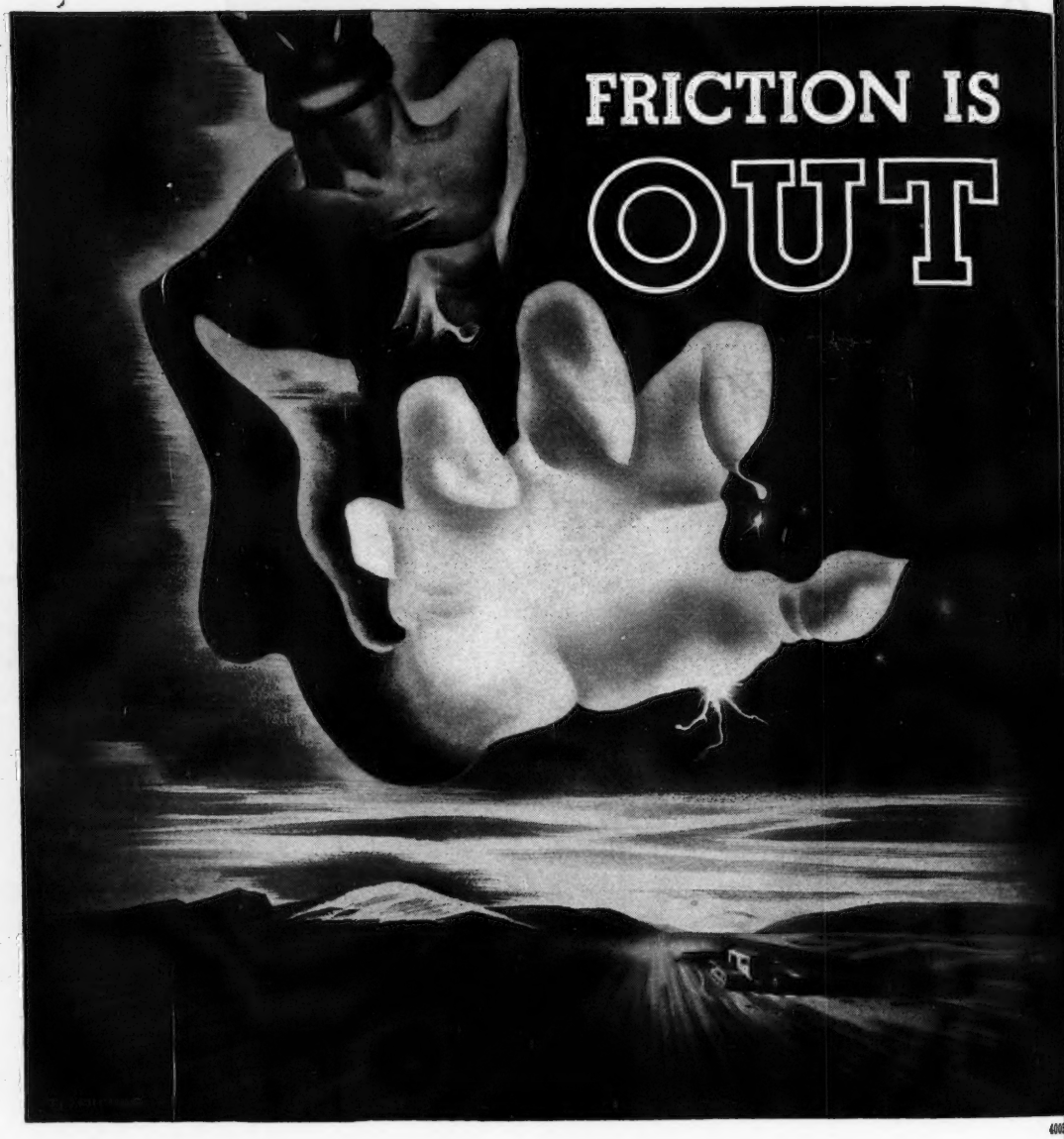
Now . . . A NEW TIMKEN FUEL INJECTION PUMP *with Renewable Pumping Units*



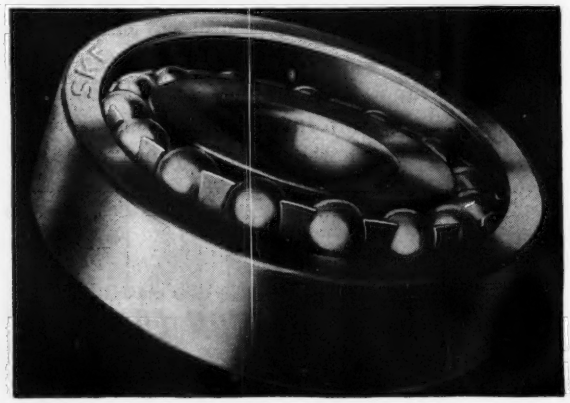
TIMKEN Fuel Injection Equipment already has gained a nation-wide reputation for outstanding performance and economy. Now we bring to operators of compression-ignition engines another big advantage—a fuel injection pump that can be kept in top-notch operating condition at all times *without being removed from the engine!* In this new pump the pumping mechanism for each engine cylinder is a compact, self-contained unit. Any individual pumping unit can be removed and replaced independently of the others. Thus, in case replacement is necessary there is no long delay while a complete new pump is obtained or the old one repaired. Instead, the pumping unit is simply slipped out of the pump body and a new one slipped in—a matter of minutes. Every engine operator will appreciate the value of this great time and money saving feature. Write for further information, mentioning the make, model and horsepower of your engine.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN
FUEL INJECTION EQUIPMENT



MODERN FARM MACHINERY IS SKF-EQUIPPED



Friction doesn't do any summering down on the farm these days. Or wintering either for that matter. For on the most modern of mechanized farms of today, plain bearings are *out*. In their place are SKF Ball and Roller Bearings, lengthening the life of equipment, reducing upkeep costs, protecting the farmer against the hazards of untimely breakdowns.

The symbol "SKF-Equipped" on anything from tractor or lighting plant up to gigantic reaper or binder, is a definite assurance of performance and quality. The demand is for SKF wherever buyers in any industry are bearing-wise. SKF Industries, Inc., Phila.

SKF BALL AND ROLLER BEARINGS

"Sure.... a spark plug in a 'Diesel'!"

In the "plain English" of John Q. Public, if an engine burns heavy fuels... injected cold... it's a "Diesel." Let the technical man quibble and limit the term to high pressure compression ignition engines... "So what?" says this tractor operator. "I know what I want."

By using a spark plug instead of great pressure to ignite the fuel, that famous Swedish engineer, Hesselman, obtained many important advantages—all found in Waukesha-Hesselman Engines . . .

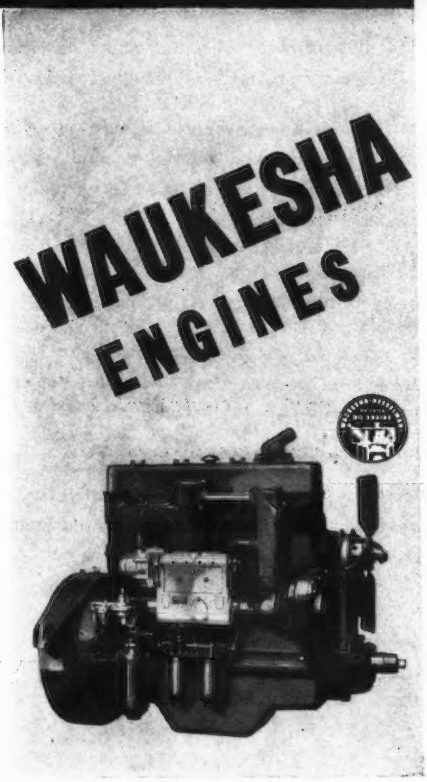
Spark plug ignition starts a Hesselman Engine easier than a gasoline engine because compression pressures can be moderate.

Spark plug ignition is *precisely timed*, not spontaneous . . . excessive cylinder pressures can't build up, thus bulky frames and flywheels are eliminated. Snappy acceleration is a Hesselman by-word.

Spark plug ignition sees all fuels in the same light—even those hard-to-fire oils that are dynamite to compression ignition engines. There is no ignition lag.

Spark plug ignition makes mechanical up-keep low, because both compression and combustion pressures are moderate. Cylinders, bearings, crankshafts are under no violent shock reversals.

Aren't all these advantages—easiest starting, snappy performance, safe working pressures, and low up-keep—worth more than a few additional gallons of 7¢ fuel oil a day? Waukesha-Hesselman Oil Engines show the *greatest over-all economy*. Actual records of their operation over thousands of hours prove it. The whole story is told in Waukesha Engineering News Record No. 5—write for a copy.



WAUKESHA MOTOR COMPANY, WAUKESHA, WISCONSIN

NEW YORK • TULSA • LOS ANGELES

THIS IS NO. 1 OF A SERIES ON THE WAUKESHA - HESSELMAN ENGINE

COMPETENCE

THE LAST WORD is never spoken. In an age of rapid progress, new requirements arise and new methods are in constant demand.

In no branch of manufacture has there been more need for ingenuity, technical soundness or honesty of product than in the field of wheel making.

It has been our privilege to serve agriculture and industry with wheels during the past fifty years. Both as originators and collaborators we have brought into being a vast variety of wheel types for virtually every wheel use and operating condition.

That we have developed a high degree of competence is attested to by the outstanding wheeled products for agriculture and industry which are strongly and dependably mounted on French & Hecht wheels.

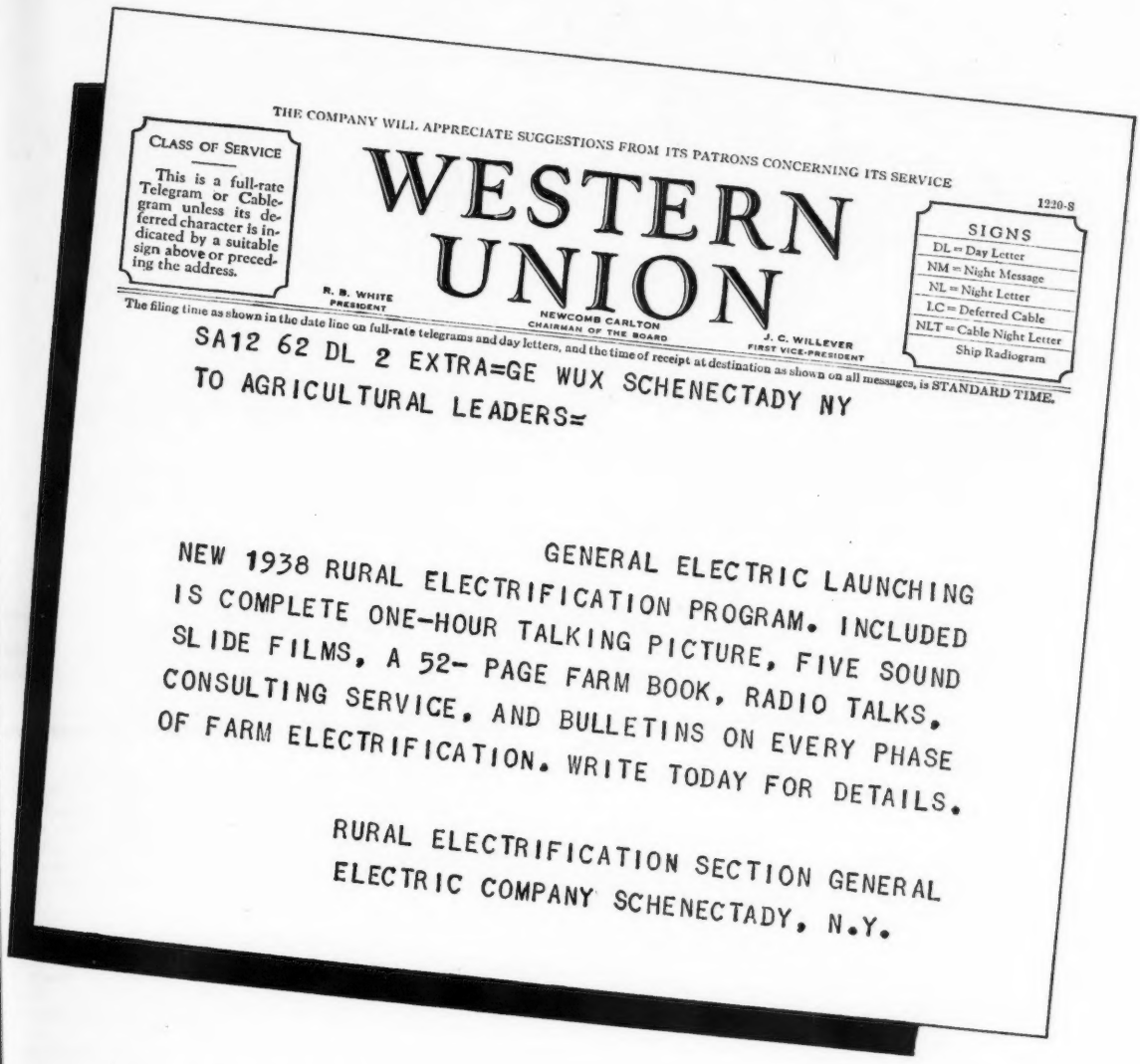
Yet the last word has not been spoken. Our engineers are constantly at work upon new developments designed to keep pace with our progressive customers and the steadily improved work methods of agriculture and industry.

We pledge ourselves to maintain the traditionally high standards of French & Hecht wheel quality, and to assist manufacturers to meet, wheel-wise, the new demands and opportunities which the coming years will disclose. French & Hecht, Inc., Davenport, Iowa; Springfield, Ohio.

FRENCH & HECHT

Wheel Builders Since 1888

Are You Prepared for 1938?



THE COMPANY WILL APPRECIATE SUGGESTIONS FROM ITS PATRONS CONCERNING ITS SERVICE

CLASS OF SERVICE

This is a full-rate Telegram or Cablegram unless its deferred character is indicated by a suitable sign above or preceding the address.

WESTERN UNION

1220-S

SIGNS
DL = Day Letter
NM = Night Message
NL = Night Letter
LC = Deferred Cable
NLT = Cable Night Letter
Ship Radiogram

R. B. WHITE, PRESIDENT — NEWCOMB CARLTON, CHAIRMAN OF THE BOARD — J. C. WILLEVER, FIRST VICE-PRESIDENT

The filing time as shown in the date line on full-rate telegrams and day letters, and the time of receipt at destination as shown on all messages, is STANDARD TIME.

SA12 62 DL 2 EXTRA=GE WUX SCHENECTADY NY
TO AGRICULTURAL LEADERS=

GENERAL ELECTRIC LAUNCHING NEW 1938 RURAL ELECTRIFICATION PROGRAM. INCLUDED IS COMPLETE ONE-HOUR TALKING PICTURE, FIVE SOUND SLIDE FILMS, A 52- PAGE FARM BOOK, RADIO TALKS, CONSULTING SERVICE, AND BULLETINS ON EVERY PHASE OF FARM ELECTRIFICATION. WRITE TODAY FOR DETAILS.

RURAL ELECTRIFICATION SECTION GENERAL ELECTRIC COMPANY SCHENECTADY, N.Y.

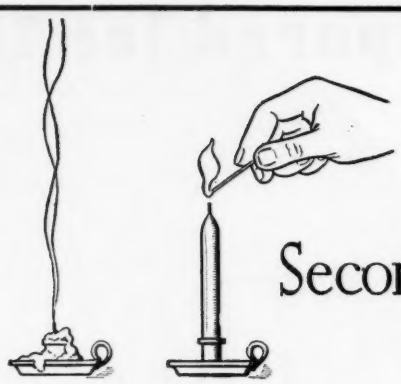
Farm Families

continue to look to you for sound advice on rural electrification. For years G.E. has made all kinds of educational material available to you. In 1938 we offer you an even more complete array of modern educational "tools" with which you can guide your farm families to an intelligent use of electricity.

Write today for complete details of this rural electrification program

GENERAL ELECTRIC

521-30H



The Second Hundred Years—

TO HAVE SERVED the farmers of America for one hundred years in the manufacture and sale of high-quality implements is to have acquired a trust that involves an obligation for the future.

Our pledge, as we pause at the beginning of the second hundred years, is that this trust shall never be violated. The confidence of agricultural America, gained by following a rigid policy of offering quality farm equipment at a fair price, is a most cherished possession of the John Deere organization.

John Deere - Moline, Ill.

- Quality Farm Equipment Since 1837 -

Agricultural Engineering Digest

(Continued from page 86)

CURING AND STORING SWEET POTATOES WITHOUT ARTIFICIAL HEAT, *W. D. Kimbrough.* Amer. Soc. Hort. Sci. Proc., 32 (1935), pp. 456-459. Keeping of sweetpotatoes in storage, according to results at the Louisiana Experiment Station, has differed little as to amount of shrinkage or rot whether or not artificial heat has been provided. In the Sunset district large quantities of sweetpotatoes have been stored in buildings similar to warehouses, and the roots themselves seem to provide enough warmth during cold spells to obviate artificial heating during storage. Most of the crop is dug in October, which is comparatively warm and usually dry.

THE HOMEMADE CENTRIFUGAL PUMP, *O. W. Monson and H. E. Murdock.* Montana Sta. Circ. 150 (1937), pp. 20, figs. 3. This circular replaces Bulletin 324 which describes the homemade centrifugal or box pump which has been developed by the station. This pump is capable of delivering a volume of water sufficient for irrigation when operated under a low lift. Tests showed that it will be practical as an irrigation pump for lifts of less than 12 ft, particularly if the pumping season is short and investment in high-priced commercial equipment is not justified.

The pump consists of a well or discharge box built from matched lumber, the height of which is equal to the operating lift plus about 3 ft for submergence. At one side of the discharge box is an impeller chamber housing a double impeller mounted on a shaft supported on a thrust bearing. The impeller is driven by means of the pulley at the upper end of the shaft.

The water enters the impeller chamber through two intake holes around the impeller shaft, one at the top and the other at the bottom. As the water enters the impeller it is thrown outward by the centrifugal force of the rotating impeller and collects in a spiral around the outside of the impeller and is guided or conveyed into the discharge box.

ROTARY SPRAY IRRIGATION, *O. E. Robey.* Michigan Sta. Quart. Bul., 19 (1937), No. 4, pp. 212-217, figs. 5. Information is given on the mechanical details of equipment used for rotary spray irrigation.

USE OF CONCRETE ON THE FARM, *T. A. H. Miller.* U. S. Dept. Agr., Farmers' Bul. 1772 (1937), pp. [2] + 60, figs. 39. This bulletin discusses the requirements of good concrete for different purposes and describes methods of building some simple concrete structures useful on the farm. It supersedes Farmers' Bulletins 1279 and 1480. It was prepared with the cooperation of the Massachusetts State College and the North Dakota Agricultural College.

STRIP CROPPING FOR SOIL CONSERVATION, *W. V. Kell and G. F. Brown.* U. S. Dept. Agr., Farmers' Bul. 1776 (1937), pp. II + 37, figs. 31. This bulletin reports the results of a study of strip cropping practices now under way throughout the United States and presents information including the latest developments in this field of work. It supersedes Leaflet 85.

The three types of strip cropping discussed are contour strip cropping, field strip cropping, and wind strip cropping.

SASH GREENHOUSES, *J. H. Beattie.* U. S. Dept. Agr. Leaflet 124 (1937), pp. 8, figs. 4. Practical information is given on the planning and construction of sash greenhouses for use in situations where a forcing structure is needed for a brief period for starting early plants and for similar purposes.

Sash greenhouses are usually constructed of 3 by 6-ft hotbed sashes with a wooden framework to support them. These structures may be of various sizes, but both width and length are made to suit the 3 by 6-ft sashes. In general, sash greenhouses are small, as the cost of large ones might easily be as much as that of standard sash-bar structures. The lean-to sash greenhouse built with a roof of sashes against the south side of a building or a tight board fence is the simplest type. Sash greenhouses may be heated by stoves, flue heaters, or steam or hot-water systems.

Illustrations are given of typical structures.

COMPARATIVE TESTS OF SEED DRILLS USED IN VEGETABLE PRODUCTION, *C. M. Agnew and H. D. Brown.* Ohio Veg. Growers Assoc. Proc., 22 (1937), pp. 5-11, fig. 1. Investigations conducted at Ohio State University to determine the advantages and disadvantages of several mechanical features of a number of drills are briefly reported, these being preliminary to the development of more effective tools for planting and fertilizing vegetable crops. The results are presented in brief tabular form, but no conclusions are drawn.

(Continued on page 94)

Even teams can't work here *but* . . .

ATLAS EXPLOSIVES *can!*

Gully control work often consists of small operations — widely separated. Power equipment won't solve the problem—even *teams* are impractical.

What is the answer to this "help wanted" question?

Many say "Atlas explosives!" And —Atlas explosives have excellent "references."

They are easily transported. They are easy to use. Their controlled force . . . exerted when you want it as you want it . . . represents the utmost in effectiveness and economy.

Atlas manufactures explosives for all kinds of work. And—Atlas will gladly assist in the selection of the best methods of usage.

The free booklet "Gully Control with Explosives" is one of the many Atlas publications which contain much useful information.

Address the Atlas office nearest you for a free copy.

ATLAS POWDER COMPANY, WILMINGTON, DEL.

Cable Address—Atpowco

Everything for Blasting

OFFICES

Allentown, Pa.	Houghton, Mich.	Memphis, Tenn.	Pittsburg, Kansas	Seattle, Wash.
Boston, Mass.	Joplin, Mo.	New Orleans, La.	Pittsburgh, Pa.	Spokane, Wash.
Butte, Mont.	Kansas City, Mo.	New York, N. Y.	Portland, Oregon	St. Louis, Mo.
Chicago, Ill.	Knoxville, Tenn.	Philadelphia, Pa.	Salt Lake City, Utah	Tamaqua, Pa.
Denver, Colo.	Los Angeles, Calif.	Picher, Okla.	San Francisco, Calif.	Wilkes-Barre, Pa.

ATLAS EXPLOSIVES

CHEMICALS ATLAS EXPLOSIVES

WORLD'S LARGEST PRODUCER OF RUBBER DEVELOPS A NEW SCIENTIFIC TIRE FOR POWER FARMERS
...The NEW
U.S. FARM TRACTOR TIRE
New Features Speed Up Farm Work!
Be sure to see this new tractor tire with its advanced lug type tread, especially engineered to speed up farm work and pull more smoothly. We invite you to see for yourself how new performance features reduce costs. Special information now available for agricultural engineers.
Specify U. S. FARM TIRES on your new equipment
SAVES TIME...FUEL...
REPAIRS...MACHINERY
1. MORE TRACTION—New type lugs...perpendicular face for deeper bite, buttressed at rear for hardest pull.
2. SELF CLEANING—Ejects as it rolls. Spacing between lugs scientifically shaped and tapered to expel mud and dirt automatically.
3. LONGER LIFE—Lugs firmly braced. Broader at center where wear is greatest...extend into connecting center riding rib of tough Tempered Rubber.
4. WEATHER-PROOFED—Both rubber and cords specially processed for resistance to sun and weather for life of tire.
5. SMOOTH PULL—Deep biting lugs in staggered formation engineered to give uniform smooth pull...reduce strain on gears and bearings.
The NEW U.S. FARM TRACTOR TIRE
United States Rubber Company
U. S. Tire Dealers Mutual Corporation
1790 Broadway, New York

Agricultural Engineering Digest

(Continued from page 92)

PORTABLE SEED CLEANING AND TREATING EQUIPMENT, *C. E. Skiver.* Indiana Sta. Circ. 230 (1937), pp. 10, figs. 4. This equipment is described and illustrated and information given regarding its use.

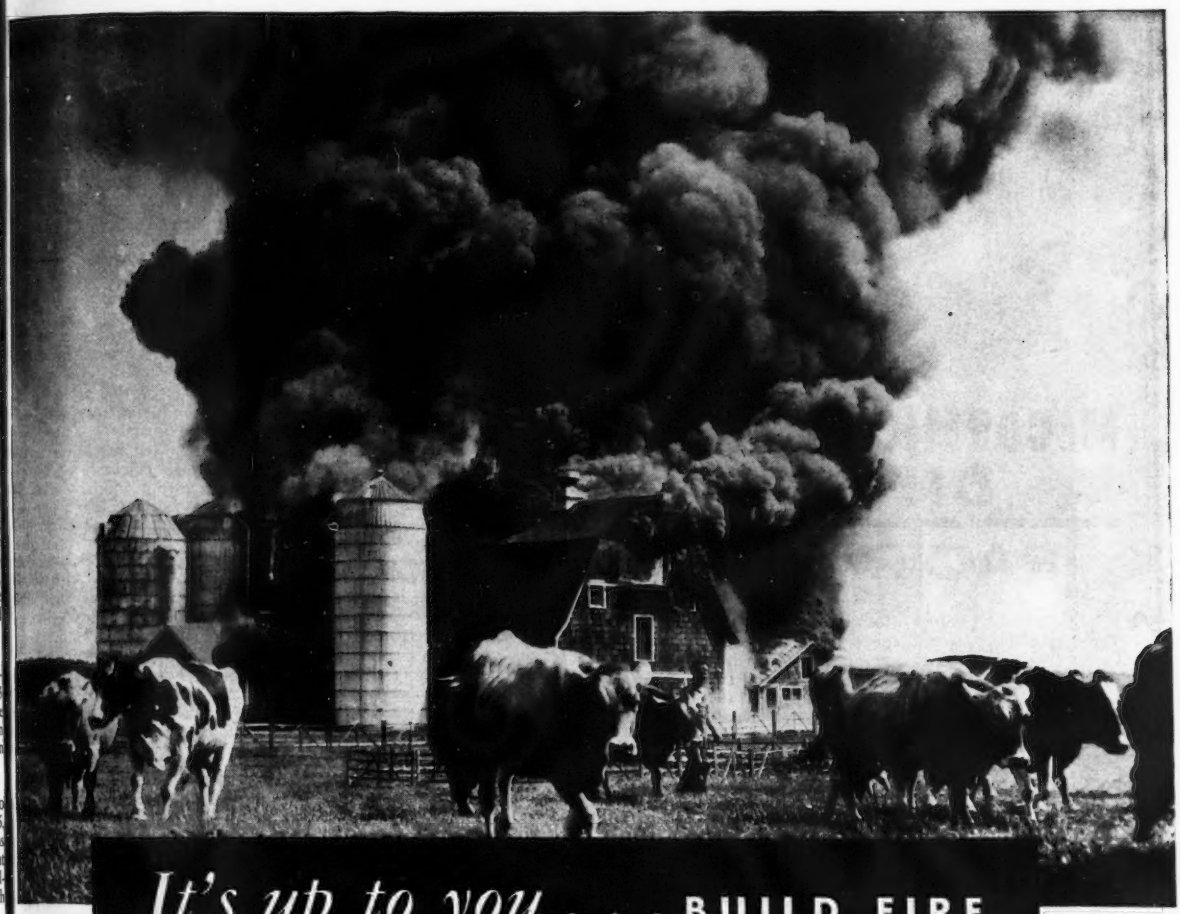
The seed cleaning equipment available to the Indiana farmer is a small farm type fanning mill of his own or the receiving separator of the nearby elevator. The separation made by the fanning mill is dependent upon two factors, specific gravity and size. The foreign material lighter than the seeds is blown out by the air blast, while those particles of the same specific gravity, yet smaller than the seeds, are removed by the bottom screen. The small mill is hardly adequate to properly clean the bulky field seeds. The receiving separators in the country elevators are regulated for the cleaning of commercial grain stocks and do not clean close enough to make the difficult separations that are necessary for the proper preparation of seed.

The portable seed cleaning and treating unit which travels from farm to farm and cleans or treats the seed offers an excellent solution to the problem when properly handled. The portable equipment has the following advantages: (1) It provides the services of improved cleaning and treating equipment, such as the large type fanning mill with traveling brushes, the disk separator, and the automatic treater that most farmers cannot afford to own; (2) it is more economical to transport the equipment to the grain than it is to bring the grain in to a central point (stationary cleaner); (3) it saves labor by making all operations such as weighing and sacking, automatic; and (4) the portable feature enables the equipment to be utilized for a long period each season, thus warranting the investment.

GETTING THE MOST EFFECTIVE RESULTS FROM PLANT REFRIGERATION SYSTEMS, *L. C. Thomsen.* Ice Cream Trade Jour., 33 (1937), No. 5, pp. 23, 24, 38. In a brief contribution from the Wisconsin Experiment Station some of the differences between dairy plant refrigerating systems are pointed out and data on operation analyzed.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE IDAHO STATION, *H. Beresford.* Idaho Sta. Bul. 221 (1937), pp. 12-16, fig. 1. The progress results are briefly presented of investigations on irrigation, drainage, and land development; plow development for pea weevil control; high-speed combines for peas; alcohol-gasoline blends for engine fuel; farm building failures; earth type potato storage cellars; and rural electrification.

HEADWATERS CONTROL AND USE, U. S. Dept. Agr., Soil Conserv. Serv. and Forest Serv., 1937, pp. IX + [1] + 261, pls. 2, figs. 71. This publication contains the papers presented at the Upstream Engineering Conference held in Washington, D. C., September 22 and 23, 1936. It has been published in cooperation with the U. S. Rural Electrification Administration. It contains papers on Basic Principles of Water Behavior, by T. Saville (pp. 1-15); Surface Run-Off Control, by R. E. Horton (pp. 16-49); Giving Areal Significance to Hydrologic Research on Small Areas, by M. Bernard (pp. 50-75); Influence of Vegetation on Land-Water Relationships, by I. Bowman (pp. 76-105); Management and Use of Forest and Range Lands, by E. H. Clapp (pp. 109-119); Management and Use of Agricultural Lands, Including Farm Woods and Pastures, by H. H. Bennett (pp. 120-157); Control and Use of Small Streams, by G. D. Clyde (pp. 158-178); A Survey of Effectiveness of Dams of the Soil Conservation Service (pp. 179-181); Farm Ponds for Water Supply and Flood Control, by W. H. McPheters (p. 181); Highway Construction and Water Conservation, by R. D. Brown (pp. 181, 182); Malaria Control, by L. L. Williams, Jr. (pp. 183, 184); Spreading Water Over Absorptive Areas for Storage Underground, by A. T. Mitchelson (pp. 184-187); Artificial Methods of Ground-Water Recharge, by R. Nebolsine (pp. 187, 188); Ground Water for Drought Relief, by J. Jacobs (p. 188); Zoning as a Technique for Water Conservation, by G. H. Gray (p. 188); Upstream Engineering and the Conservation of Wildlife Resources (pp. 189-192); Relationships of Animal Life to Land and Water Resources, by C. L. Forsling (pp. 193-195); Wildlife—A Land Crop Favorable to Conservation of Water and Soil (pp. 195-197); Influence of Animal Life on Soil and Water Conservation, by E. G. Holt (pp. 197, 198); Physical and Functional Relationships, by M. L. Cooke (pp. 201-209); The Comprehensive Engineering Point of View, by S. M. Woodward (pp. 210-222); Big Waters and Little Waters, by E. M. Markham (pp. 223-226); Control and Use of Little Waters in France, by M. A. Magnein (pp. 227-232); Building Toward a Permanent Agriculture, by J. G. Lipman (pp. 233-236); On Behalf of a Continent, by M. Maverick (pp. 237-245); and The Human Value in Upstream Engineering, by C. H. Whitaker (pp. 246-249). *(Continued on page 96)*



It's up to you . . . BUILD FIRE OFF THE FARM WITH CONCRETE

AGRICULTURAL engineers have accepted the responsibility of leadership in the design of farm structures. Thanks to their efforts, recent years have seen tremendous progress in the development and testing of suitable structures for various conditions and purposes.

But leadership cannot rest. Solving these fundamental problems has simply opened the way to further progress. Today, the engineer can no longer design solely for "use requirements." He must look beyond to the vital factors of economy, permanence and, most of all, *firesafety!*

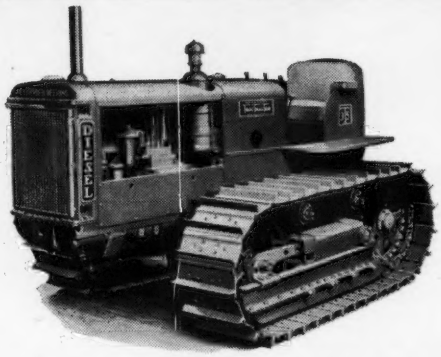
Mere statistics—no matter how large the figures—cannot adequately describe the tragedy of farm fires. There is no hope of altering the conditions of isolation and the absence of fire-fighting equipment which makes these blazes tragic. The certain remedy is to *design with firesafe materials!*

Concrete construction has given you a powerful weapon in the fight against fire. For concrete won't burn! It can't be ignited by flying sparks or embers; it resists the spread of fire from adjacent buildings; it confines fire to the structure in which it originates. Yet concrete construction is available in every locality . . . compares favorably in cost with any other permanent construction . . . offers lowest upkeep through decades of satisfactory service.

Strengthen your position of leadership by giving the farmer the help he needs in building fire off the farm. Recommend concrete walls and floors, and a firesafe roof for all permanent farm dwellings. Our agricultural engineers will gladly confer with you on design questions involving the use of concrete.

PORTLAND CEMENT ASSOCIATION
Dept. A2-1, 33 W. Grand Ave., Chicago, Ill.
A National Organization to Improve and Extend the Uses of Concrete

FIRESAFE CONSTRUCTION IS THE BEST FIRE PROTECTION



McCORMICK-DEERING DIESEL TRACTRACTORS

The McCormick-Deering Model TD-40 DIESEL TracTrac-Tor has a long record for serving agriculture, offering exceptional economy and accessibility. Now the *new* Model TD-35 DIESEL (shown above) brings you all the advantages of Diesel power and crawler performance in a somewhat smaller tractor at a lower price. Complete details will be supplied on request.

INTERNATIONAL HARVESTER COMPANY
(Incorporated)
180 No. MICHIGAN AVE. CHICAGO, ILLINOIS

the BADGE of him who BELONGS

DESPITE the *presumption* it sets up, mere membership in the American Society of Agricultural Engineers is no *proof* of a man's high rank in technical talent. It does prove that he has met certain minimum requirements and has earned the esteem of colleagues who sponsored his application for membership.

But the Society emblem is *evidence* that native talent, be it great or small, is enriched by fraternity with the personalities whose minds fuse to form the pattern of progress in the methods and mechanics of agriculture. The wearer of the emblem waits not for the debut of an idea, but is present at its birth and helps to guide its growth.

Be you novice or veteran, your membership in the organized profession adds something to your efficiency, your vision, your influence as an individual engineer. The Society symbol on your lapel is token that you "belong." Wear it.

STYLES AND PRICES OF ASAE EMBLEMS

With blue ground for Members and Associate Members—furnished either in pin with safety clasp or lapel button—$2.00 each.

With red ground for Junior Members, Affiliates, and Student Members—furnished only in pin with safety clasp—$1.00 each.

Send orders to ASAE, St. Joseph, Michigan.

Agricultural Engineering Digest

(Continued from page 94)

EFFICIENCY OF HORSES, MEN, AND MOTORS, *S. Brody and E. A. Trowbridge.* Missouri Sta. Bul. 383 (1937), pp. 24, figs. 7. This bulletin presents a study of various factors concerning efficiency of horses, men, and motors, as follows: Speed, load, size of animal, path of reaching maximum efficiency, relation between all-day efficiency and efficiency while working, energy costs as related to speed, load, and work, comparative abilities of horses and men, and factors limiting work output and efficiency. A feeding standard for horses is also suggested.

Optimum or best speed for maximum efficiency is a compromise between muscle viscosity, which requires slow movement for most efficient work, and overhead maintenance cost, which requires rapid movements for most efficient work. Data studied indicate the probability that every horse and man has a characteristic efficiency curve. Efficiency tends to rise with increasing load until an optimum load and maximum efficiency are reached. Efficiency becomes less as the load is increased thereafter.

The size of animal does not seem to influence maximum efficiency, since all animals studied had approximately a 24-per cent efficiency level. Efficiency begins at zero, (when the horse is doing no work), and builds up to a maximum efficiency of 24 per cent in a manner similar to the way a growing animal builds up to maximum body weight. The fewer the working hours per day the lower the all-day efficiency. When working at the rate of 1 hp the efficiency of the horse is about 17 per cent for a 12-hr day, 14 for an 8-hr day, 10 for a 4-hr day, and 7 per cent for a 2-hr day.

Energy expenditure increases in direct proportions with speed of pulling given loads, with load pulled at given speeds, and with horsepower. Increasing horsepower output demands proportionately increased energy expenditures. Horses and man have the same work energy to basal energy ratios, namely, 20 for maximum oxygen consumption (not including oxygen debt), 100 for maximum brief effort involving great oxygen debt, and 8 for sustained hard work as encountered in daily life. Temperature, humidity, kind of feed, training, and physical conditions are definitely related to energy efficiency. The energetic efficiency and economy of the horse and mechanical power depend upon many factors and vary accordingly. A feeding standard is set up. The use of horse, mule, or mechanical power depends upon kind of work, availability of power, and feed or fuel for its operation.

AGRICULTURAL ENGINEERING INVESTIGATIONS BY THE NEBRASKA STATION, Nebraska Sta. Rpt. [1936], pp. 5-7. The progress results are briefly presented of investigations of feed processing methods, cooling milk, heating water for livestock, electrically heated hotbeds, insulated electric brooders in uninsulated poultry houses, performance of rubber tires on tractors, and bindweed eradication machinery.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS OPEN

DESIGNER familiar with grain, hay, and farm machinery is offered an excellent opportunity by a leading manufacturer of farm equipment. PO-115

DESIGNER, who is an experienced graduate engineer, is wanted by a farm equipment manufacturer for designing agricultural implements. PO-120

POSITIONS WANTED

AGRICULTURAL ENGINEER, farm reared, 1932 graduate of the University of Illinois majoring in farm machinery, four years' experience in ECW and SCS camps in all positions, worked part time while attending the University at agricultural engineering department in maintenance work, desires position with machinery manufacturer in maintenance work, or as a demonstrator. Location immaterial. Married. Age 27. PW-286

AGRICULTURAL ENGINEER, graduate of Kansas State College 1934, with experience in drainage and irrigation work, desires to obtain a permanent connection. Now employed. Single. 2[illegible] years old. Can give good references. PW-287